SCIENTIFIC AMERICAN

No. SUPPLEMENT 834

Copyright by Munn & Co., 1891.

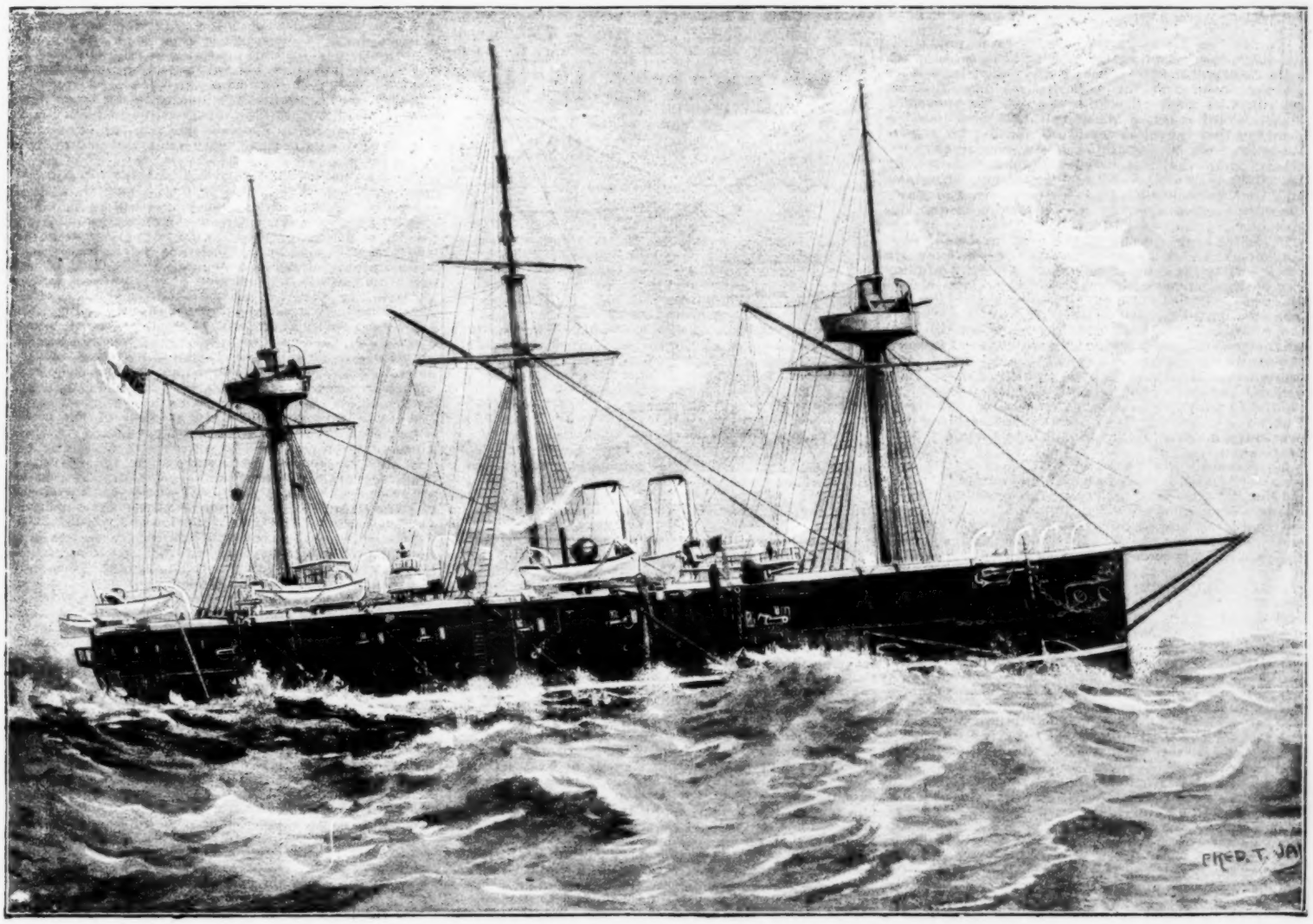
Scientific American Supplement Vol. XXXII. No. 834
Scientific American, established 1845.

NEW YORK, DECEMBER 26, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

H. M. S. NELSON.

THE Nelson, which we illustrate, has taken the place as flag-ship of the old Duke of Wellington, 121 guns, the last wooden three-decker built for the British Navy, and first commissioned during the Crimean war. The Nelson was built in Glasgow, and completed in 1889. She is 280 ft. long, 60 ft. beam, and 7,630 tons displacement. Her engines, by Elder, give her a speed of fourteen knots. She is sheathed with zinc. Her side armor is 9 in. and 6 in. thick. She is stated in Brassey's "Naval Annual" to carry four 18 ton muzzle loading guns, eight 12-ton muzzle loaders, four 4·7 in. quick fire guns, and twenty quick firing guns of small caliber, eight machine guns, and one boat gun. The latest modification in the rig of the ship is shown in our illustration.—*The Engineer.*



HER MAJESTY'S BATTLE SHIP NELSON.

RECENT PROGRESS IN THE SCIENCE OF MAGNETISM.*

By B. S. GILES.

THE nineteenth century has been pre-eminently marked by the most wonderful and rapid advances in all branches of science. Its history records searching and indefatigable inquiry, accompanied or followed by startling revelations and brilliant success.

Probably no two branches have shown more rapid development than electricity and magnetism, and, indeed, it seems quite natural that the newest sciences will have the quickest growth, not only because there are more workers in the field, but also because the principles and the known facts and the best instruments of the older sciences can be applied to their investigation. At the beginning of the century electricity and magnetism were hardly worthy to be called sciences. Although a few facts were known about each, scarcely any of them had a rational explanation, and they were demonstrated and dismissed as very interesting and curious phenomena; the attachment of the probable physical interpretations has been reserved to physicists of the last few decades.

Now these two branches are so closely connected that it is difficult to deal with one without frequent reference to the other, because among the most famous and useful discoveries in them have been those proving the intimate relations which exist between them, such as Faraday's discovery that when a closed coil of wire is made to move in a magnetic field, so as to alter the number of lines of force which thread through the coil, a current of electricity is set up in it; and the equally important discovery that the strongest magnets are made by passing electric currents round iron cores. But in spite of this close connection, the state of magnetism may, as far as our limited knowledge goes, exist independently of any state of electrification or of the energy of the electric current. Whether or not this is so, the consideration of the recent progress in the science of magnetism alone is sufficient for our present attention. In what follows I purpose to give a brief *resume* of the work which recent experimentalists have done, and afterward specially to discuss the theories which have been advanced to account for the phenomena observed.

About sixty years ago Faraday commenced those researches which indicated his extraordinary aptitude for original work, and which have since made him famous; but his attention was at first confined chiefly to electrical investigations and it was through electricity that he first studied magnetism, in consequence of the connecting link which exists in the electromagnet. Before this, very little had been done, beyond some experiments made in 1822, by Barlow, on the magnetic action of iron between red and white heat, closely followed by Christie's investigations, in 1825, of the effect of temperature on magnetizing forces.

In 1838, Gauss made the first determinations of the horizontal component of the earth's magnetism, and the value and accuracy of his methods are shown by the fact that they are still employed and called by his name. The earth's magnetism has, ever since the realization of its existence, been a source of much inquiry and speculation; for many years the compass needle was almost the only practical application of the magnet, and in consequence of this and its great value for purposes of navigation, it received a large share of attention. The diurnal, annual, and secular variations have also been the objects of numerous observations, and it is rather surprising to find what a great deal has been published from year to year in this direction. Indeed, except for the publication of these tables of statistics, the science of magnetism would apper to have been at times neglected for years consecutively.

Passing rapidly over the interval between 1830 and 1855, the record of Faraday's "researches" might almost be regarded as a history of the science during this period. The great investigator seems to have been always in advance of his times, and he and a few of his contemporaries who might be mentioned, such as Ampere and Arago, gave to the world what are now regarded as fundamental principles. In 1845, Faraday examined the action of magnets on light, especially on the polarization of light, and in the following year turned his attention to diamagnetism, but does not seem till a few years later to have formed any idea of magnetic resistance, which is so necessary in accounting for this phenomenon. In 1851 he examined the action of gases placed in magnetic fields, and found that oxygen is decidedly paramagnetic, and that its paramagnetic force decreases with temperature. He accounted for diurnal, annual, and secular variations by the constant variation of the elements, and especially by changes of temperature caused by the sun. At the same time he began to entertain clear views of "lines of magnetic force," and even went so far as to indicate that they must always form closed curves. At first he brought forward this conception as a hypothesis, but afterward expressed his strong belief in the physical existence of these lines. Being essentially an experimentalist and not a mathematician, the quantitative treatment of the science Faraday wisely left to others.

Wiedemann, in 1861, related his discovery of the mag-

* Being the paper which gained the prize in the Owens College Physical Laboratory.

netism which an electric current produces (in an iron wire, and, besides much other good work, brought out a treatise of sterling merit, entitled "Galvanismus."

Three years later Clerk Maxwell showed what an essential part the medium plays in all magnetic effects. Till the untimely close of his life, this original and deep thinking mathematician supplemented in a wonderful manner the practical work of Faraday and others, and there can be no doubt that Faraday by his "Experimental Researches," and Maxwell by his publications, have largely influenced the work and modes of thought of nearly all subsequent experimentalists and theorists.

In 1866, Wilde built his first dynamo, and soon afterward Wheatstone introduced the principle of self-excitation in these machines, but the next 10 or 12 years show very little progress except in the manufacture of dynamos, which from that time till the present have been made in great variety, and have undergone very rapid improvements.

A great revival, and one which has been the means of much enlightenment in the theory and general effects of magnetism, took place about 10 years ago. A new generation of investigators in this branch had arisen, foremost among whom must be mentioned Ewing, Hopkinson, Hughes, and others.

Sir William Thomson, who has perhaps been concerned more with electricity than with magnetism, in 1879 made a very thorough investigation of the effects of stresses on the magnetization of iron, and this has subsequently been studied by Ewing, Tomlinson, and others.

In the same year Shettle demonstrated the obliquity of the axes of bar magnets, and two years later Hughes confirmed his results by finding that a natural magnet can be produced, having its molecular arrangement of a spiral form.

Hughes had by this time brought his ingenious instrument, the induction balance, to a state of great perfection; and in spite of many who failed to see its practical utility, though admiring its ingenuity, he used it with good effect to investigate the molecular conditions of magnetism, and in 1883 formulated a theory of these physical conditions, basing his results almost entirely on researches made with his balance. He also found that the magnetic capacity of iron or steel is directly as its softness or molecular freedom, and that its resistance to a feeble external magnetizing force is directly as its hardness or molecular rigidity.

In 1881 Ewing discovered the very important phenomenon to which he gave the name of hysteresis. He was led up to the consideration of it by "the production of transient electric currents in iron or steel conductors by twisting them when magnetized, or by magnetizing them when twisted."* He conceives that the combined effect of torsion and of longitudinal magnetization is to produce a state in the wire which persists almost unchanged when the magnetizing force is removed. He found that the change of state "lags behind" the change of torsion, and it is this lagging behind to which he has applied the name hysteresis. The subject has occupied his attention more or less ever since, and his inquiry into it has certainly been very exhaustive.

Moreover, in 1885, he found that there is not only static hysteresis, but also a small amount of "viscous lagging," "time-lag," or "magnetic creeping" in the changes of magnetism which follow changes in magnetizing force, and he considers that the great difference in the amount of this time-lag which exists between a single thick wire and a bundle of fine wires of the same material is explained by the fact that the creeping itself sets up eddy currents which are more numerous in the solid than in the laminated bundle, and that these eddy currents react so as to retard the creeping.

As an illustration of "time-lag," I may mention some effects observed in experiments made at the Salford Iron Works, which I am permitted to refer to.

The primary object of the experiments was to measure the waste field of a few different sizes of Manchester and Edison-Hopkinson dynamos, by finding the ratio of the total number of force induced in the magnets to the number passing through the armature core. As they all, more or less, illustrate the point in question, I have selected the figures of one machine only, viz., a No. 6 A Manchester dynamo with an armature core 13¾ in. diameter.

The Manchester dynamo, being of the double horseshoe pattern, with a ring armature, twelve convolutions of wire were taken round the middle of each magnet limb, and the two coils joined in series; two diametrically opposite sections of the bare core were likewise wound each with twelve convolutions, and the two coils joined in series, and the core placed in the fields so that the maximum number of lines of force passed through the coils. If the free ends of the coils be connected to a ballistic galvanometer, the throws obtained on suddenly magnetizing and demagnetizing the magnet limbs are proportional to the induction, and the ratio of throws obtained from the magnets to those obtained from the armature is the ratio required. The object of using so many convolutions was only to obtain a large deflection, and to make the direct action of the field on the galvanometer small in comparison to the throws obtained from the coils.

The field was suddenly made with 100 volts across the magnets, and suddenly short-circuited, alternately, by means of a hatchet switch, this being found the best way of insuring instantaneous change.

A reversing key was used, so that the deflections could always be read in the same direction, and the connections were arranged so that the small direct action of the fields should oppose the throw on making and assist it on short-circuiting, which is equivalent to breaking.

Now, this experiment has been made previously by Drs. J. and E. Hopkinson† and others, but the statement has generally been made that throws on make and break will be equal.

I found, however, that the make was always greater than the break, as the following figures show, in spite of the fact that the direct action of the field was to oppose the make and help the break. If this be allowed for by adding a small quantity to the former and subtracting the same quantity from the latter, the effect is more marked:

(1) Magnets connected—

Make = 567 divisions.	Break = 504 divisions.
Make = 576 divisions.	Break = 506 divisions.
Make = 580 divisions.	Break = 508 divisions.
Make = 582 divisions.	Break = 510 divisions.
Mean make = 576.	Mean break = 507.

(2) Armature connected—

Make = 388 divisions.	Break = 308 divisions.
Make = 398 divisions.	Break = 307 divisions.
Make = 382 divisions.	Break = 310 divisions.
Make = 403 divisions.	Break = 317 divisions.
Mean make = 393.	Mean break = 310.

The direct action of the field was to move the needle twenty divisions during the time of the first swing of the magnet throws, and fifteen divisions during the armature throws.

The final values thus become:

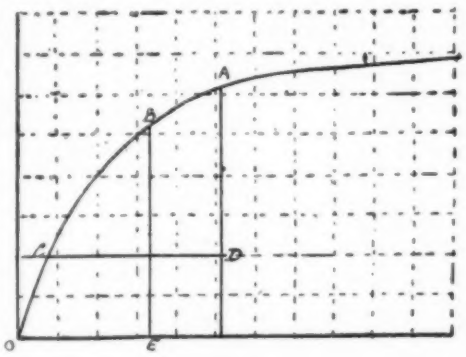
$$\begin{aligned}
\text{Magnet make} &= 576 + 20 = 596.\\
\text{Magnet break} &= 507 - 20 = 487.\\
\text{Armature make} &= 393 + 15 = 408.\\
\text{Armature break} &= 310 - 15 = 295.\\
\text{Ratio required} &= \frac{596 + 487}{408 + 295} = 1{\cdot}54.
\end{aligned}$$

This means that out of every 154 lines of force which pass through the magnets, 100 pass through the armature.

It occurred to me that this well-marked difference between make and break might possibly be due to the "time-lag" observed by Ewing.

If the characteristic curve of the dynamo were a straight line, then, in spite of hysteresis and time-lag, the make would always be equal to the break, but inasmuch as we are working on the bend of the curve the former is greater than the latter, and the stronger the field employed, the greater will the difference become.

The conditions might be represented diagrammatically thus:



Suppose that with 100 volts across the magnets we are working on the part of the characteristic curve marked A. Then, on suddenly breaking, the induction will not at once fall to 0, but in the time during which the needle completes its first swing will fall, say, to some point, C, and A D will be proportional to the throw. On again making, the induction will not at once rise to A but to a point, B, such that the arc O B = the arc A C, and B E will be proportional to the throw, so that the ratio of make to break will be the ratio of B E to A D.

In the relation of change of magnetization to temperature, Ewing found that there is no hysteresis, the reason possibly being that change of temperature cannot take place without vibration of the molecules, but he observed well marked hysteresis in the effects of stress on the thermo-electric quality of iron. The similarity of the plotted curves in this case to those which illustrate the hysteresis exhibited in the effects of stress on the magnetization of iron suggest that the former effect is secondary to the latter.

This possibility occurred to Ewing, who immediately proceeded to investigate it. His experiments conclusively proved that stress does not affect the thermo-electric quality of iron by first producing a change in its state of magnetization, though any magnetism present modifies the result, and that, therefore, the hysteresis of thermo-electric change is quite distinct from the hysteresis exhibited in changes of magnetization, though, perhaps, both are assignable to the same peculiarity in the molecular constitution.

Warburg had discovered that the area inclosed by the ascending and descending curves of magnetization in a complete cycle is a measure of the energy expended in producing the cycle. Ewing soon independently realized this fact and expressed the energy quantitatively. The amount of this energy turned out to be a much smaller quantity than some had supposed, and his experiments led him to a very important practical conclusion. It had been suggested that, assuming the loss of energy due to mere reversal to be considerable, a great saving might be effected by building the armatures of dynamos without cores, but Ewing was able to point out that since the energy expended in mere reversal is very small in amount in soft iron, the power absorbed in the armature is due, first, to the loss in the coils due to the main current, and, second, to eddy currents developed in the core and in the coils, and, therefore, if soft iron is used and thoroughly laminated, the efficiency will not be less than in an armature without a core. As a matter of fact it will be much greater, because of the great increase of waste field when cores are dispensed with.

Ewing at about the same time entered very fully into the question of retentiveness, and found, contrary to the generally accepted opinion before, that soft iron is much more retentive than hard iron or steel when quite undisturbed; but that vibration has an enormous effect on the retentiveness. It was probably this action of vibration, in causing iron to lose its residual magnetism, which led to the erroneous impression that retentiveness varies directly as the rigidity of the molecules.

Ewing lays great stress on the importance of the absence of all mechanical disturbance, as he found that even a light footstep in the corridors adjacent to the rooms in which he experimented was sufficient to make a very great difference in the residual magnetism of soft iron.

He summarized the results of his experiments on the ratio between residual and induced magnetism as follows:

"When the induced magnetization is very weak, it almost all disappears on the removal of the inducing force.

"When it is increased, its capability of being retained also increases very rapidly, and the ratio of residual to induced magnetism reaches a maximum.

"The value of the maximum is from 0·84 to 0·93 in annealed iron, nearly as great in annealed, hardened, or tempered steel, but much less in hard-drawn iron, where its value is more like 0·6. . . .

"As the magnetization is further increased, the residual magnetism approaches saturation more rapidly than the induced, and consequently the ratio diminishes—slightly in soft iron, more in steel, and much more in hard-drawn iron."*

He even goes so far as to say that he thinks very soft iron might, under certain theoretical conditions, possess perfect retentiveness.

During the last three or four years nickel has received a greater share of attention. Of course, this metal is not nearly as interesting as iron from a practical point of view, nor is there room for so much investigation in it; but, nevertheless, the study of it and of cobalt is very helpful in forming a true conception of the real physical nature of magnetism.

In 1888, Ewing found that longitudinal pull reduces both induced and residual magnetism in nickel, and that, as Sir William Thomson had pointed out as possible in 1879, longitudinal compression had just the opposite effect.

The converse of these physical processes was investigated by Shelford Bidwell. He found that the length of iron is increased up to a certain critical value of the magnetizing force, when it reaches a maximum; beyond this value the elongation is diminished, and if the force is further increased the iron regains its original length and eventually undergoes retraction. I believe no explanation has yet been offered of this subsequent retraction. In the case of a nickel bar the length is diminished by magnetization from the beginning.

Bidwell's first experiments were made on rods. As doubts had been expressed about the value of some of his results, in consequence of some of the means which he employed, he substituted rings for the rods, and with many improvements on his original apparatus confirmed his previous conclusions.

We will now glance briefly at some of the work done and conclusions arrived at by Dr. John Hopkinson.

In 1886 he selected for investigation the effects of impurities on the magnetization of iron. His results are very instructive, particularly those on the effects of small quantities of manganese on the electrical and magnetic properties of iron. He found that the introduction of only 12 per cent. of manganese renders iron non-magnetic, and pointed out that the manganese must be regarded as entering the molecules of iron and completely changing their properties.

He examined the effect of a large number of other foreign bodies on iron, and concludes by saying that we are a very long way from obtaining a range of facts sufficiently extended for testing a complete theory of magnetism.†

In 1889 he published the results of some very careful investigations of the magnetism and general magnetic properties of iron at high temperatures, from which it appears that when a small magnetizing force is employed and kept constant, the magnetization of iron steadily increases with rise of temperature, till it begins to approach the "critical temperature." Just before this temperature is attained the magnetization increases very rapidly, but as soon as it is reached and exceeded the iron loses very nearly all its magnetism, and can be thoroughly demagnetized by employing a very high temperature, but even then the iron regains some of its original magnetism when subsequently cooled. The "critical temperature" varies from 690 deg. C. to 870 deg. C., according to the quality of the material.

He also found that "regarding the iron as made up of magnetic molecules the axes of which are directed to parallelism by magnetic forces, the magnetic moment of the molecule diminishes with rise of temperature, at first slowly, but very rapidly as the point is approached at which magnetism disappears. On the other hand, the facility with which the molecules are directed continually increases, at first slowly, but at high temperatures very rapidly. The effect is that at a temperature = 720 deg. C., an exceedingly small force is competent to turn the axes of nearly all the molecules in a direction parallel to the magnetizing force."‡

I think this last effect is just what might be expected as the iron approaches to the condition of a fluid, and seems to be a continuation of the fact that soft iron is much more susceptible to induced magnetism than hard iron.

Dr. Hopkinson here points out two distinct and opposite effects of increase of temperature. Probably if the effect on the magnetic moment were to increase it instead of diminishing it, enormously powerful magnets could be produced by first heating iron to nearly the critical temperature, and saturation of induced magnetism could easily be obtained in large masses of iron.

The above sketch is necessarily but the merest outline of the work which has been done, and the discoveries which have been made in the science, for the most part quite recently. It has been my endeavor to

* *Proc.* Roy. Soc., 1881.
† *Phil. Trans.*, 1886, p. 359.

* *Phil. Trans.*, 1885.
† *Phil. Trans.*, 1886.
‡ *Proc.* Royal Society, 1889.

bring forward those researches which have resulted in the greatest practical usefulness, or which are best calculated to help us in forming a good conception of the physical cause and nature of magnetism. I will now endeavor to place together some of the leading theories which have been advanced from time to time to answer the question, "What is magnetism?"

Many of our profoundest thinkers have after careful consideration been able to offer no solution of this difficult problem, and it will be generally admitted that although at the present day we may presume to possess a fairly accurate knowledge, as far as it goes, of some of the physical conditions which exist in a magnet, the question is still unanswered, Why, when these physical conditions exist, do we get the effects of magnetism?

A few facts stand out very prominently as requiring satisfactory explanation. One of the most striking is that although there is no absolute distinction between magnetic and non-magnetic bodies, there is a very vast difference between iron, nickel, and cobalt on the one hand and all other substances on the other.

Among many other phenomena which arrest attention and demand explanation may be mentioned residual magnetism, hysteresis, induction, and the variation of its intensity with many circumstances, etc.

In the days of Sir Isaac Newton very little indeed was known about magnetism, and we look in vain for any ideas from him. This great philosopher, who stated the laws which govern the motion of bodies, and many other laws, so clearly that they are accepted now just as he enunciated them, felt incompetent to offer any explanation of magnetic phenomena; and Gilbert, with whose name is associated the first we hear of the science, contented himself with a declaration of the phenomena he observed.

Poisson and Coulomb seem to have been the first to frame a theory, and almost all subsequent theorists have agreed with them to this extent, that magnetism has a molecular nature.

They assumed that each molecule is a sphere, containing two distinct magnetic fluids, which are separated under the influence of magnetic force, and that a certain inherent coercive force keeps the two fluids from mixing in the case of a permanent magnet. Such a theory explains the inductive action which takes place between magnets and magnetic bodies, but not much more.

Sir Wm. Thomson was perhaps the first to express his disbelief in these fluids in 1849, and he established a mathematical theory founded mostly on Coulomb's researches.

Weber's theory is an improvement on Poisson's, and his views were good enough to be entertained by Clerk Maxwell with certain modifications. He held that each molecule of iron is a magnet before any application of magnetizing force, and that the axes of the molecules are turned in all directions; that the axes were deflected toward parellelism by a magnetizing force; and that each one tends to return to its initial position.

This theory would account for saturation and for some of the effects of temperature, but does not explain retentiveness, and is silent about the connection between the magnetic and other properties of iron.

Clerk Maxwell agreed with Weber in his explanation of neutrality, but offered an explanation of retentiveness based on the analogy of magnetism to mechanical strain. To use his own symbols, he supposes that when a molecule is deflected by a magnetizing force, X, it returns to its initial position when X is removed, if the angle of deflection, β, of its axis has been less than a certain limit, β_0. If, however, β_0 has been exceeded, it does not completely return, but remains with its axis deflected through an angle $\beta - \beta_0$.

But under these circumstances, as Ewing * pointed out, we should expect, on sudden reapplication and withdrawal of X, to obtain a purely elastic series of changes, so that this modification and extension of Weber's theory does not allow of the existence of hysteresis.

Ampere's theory is at first sight very plausible, and goes a little further than any other theories before or since in stating what the magnetism of a molecule actually consists of. It is based on the analogy of electric currents, and supposes that an electric current flows round each molecule in a closed circuit of no resistance, and that neutrality is due to a miscellaneous and magnetization to a symmetrical arrangement of the molecules.

This theory has this advantage—shared by no other—that it readily accounts for many of the observed connections between magnetism and electricity; but a serious objection is that, as far as we know, electric currents cannot exist without a constant expenditure of energy, and in any case we do not know what an electric current consists of.

De la Rive in 1853 held Weber's views concerning the inherent magnetism of every molecule, and the cause of neutrality; but he recognized retentiveness, and assigned it to the resistance of the molecules to change their relative positions, calling this resistance "coercitive force."

Wiedemann in his "Galvanismus" gives a molecular theory, which is in some respects the same as that held at the present day. In that work he states, and was probably the first to do so, that neutrality consists of a symmetrical arrangement of the molecules. Hughes lays claim to the first assertion of this condition of neutrality. Into the question of this priority I do not propose to enter further. In any case, Hughes in 1883 formulated a very complete theory of the physical conditions which accompany the states of neutrality and polarity, and since these assumptions, as far as they went, constituted for many years the current creed, I think they are worth stating in full.

"1. That each molecule of a piece of iron, steel, or other magnetic substance, is a separate and independent magnet, having its two poles and distribution of magnetic polarity exactly the same as its total evident magnetism when noticed in a steel bar magnet.

"2. That each molecule or its polarity can be rotated in either direction upon its axis by torsion, stress, or by physical forces, such as magnetism and electricity.

"3. That the inherent polarity or magnetism of each molecule is a constant quantity like gravity, that it can be neither augmented nor destroyed.

"4. That when we have external neutrality, or no apparent magnetism, the molecules, or their polarities, arrange themselves so as to satisfy their mutual attraction by the shortest path, and thus form a complete closed circle of attraction.

"5. That when the magnetism becomes evident, the molecules, or their polarities, have all rotated symmetrically in a given direction, producing a northpole if rotated in one direction as regards the piece of steel, or a south pole if rotated in the opposite direction. Also, that in evident magnetism we have still a symmetrical arrangement, but one whose circles of attraction are not completed except through an external armature joining both poles.

"6. That we have permanent magnetization when the rigidity, as in tempered steel, retains the molecules in a given direction, and transient magnetism whenever the molecules rotate in comparative freedom, as in soft iron."†

The last clause is not quite correct in the light of Ewing's later experiments on the ratio of residual to induced magnetism, inasmuch as soft iron is undoubtedly more retentive than tempered steel; and clauses 4 and 5 may also require considerable modification, but, nevertheless, much praise is due to Hughes for the manner in which he placed some of the physical accompaniments of magnetization almost beyond the region of speculation, by his very ingenious and indefatigable applications of the induction balance, and for the way in which, before bringing forward this theory, he submitted the statements in it to experimental demonstration, by a method of investigation which had been impossible before the introduction of the balance.

Ewing's experiments on hysteresis and retentiveness, though they do not form the basis of a new theory, are of great service in exposing the weak points of previous theories, especially those of Weber and Maxwell. When he recorded the results of those experiments † he at the same time stated that to form a mechanical conception of the process of magnetization, it is necessary to assume an elastic tendency on the part of the molecules to recover their initial position when displaced; a static frictional resistance opposing such displacement; and also a viscous resistance to the displacement—these three assumptions being intended to account for residual magnetism, hysteresis, and time lag respectively.

But quite recently Ewing's own views have undergone considerable change, in consequence of experiments which he made with a model intended to illustrate the actual movements of the molecules of magnetic bodies, and in a paper describing these experiments, which he read before the Royal Society, June 19, 1890, he says that although the motion of a frictional resistance to displacement of the molecules accounts well for hysteresis, and its reduction by vibration, it opposes the fact that some magnetism is induced even by the feeblest magnetizing force. He then proceeds to work out a theory the essence of which is that it is not necessary to suppose that any forces are constraining the molecules, except those due to their own mutual attractions and repulsions, which are quite sufficient to account for the directional stability of the molecules.

Such a theory accounts well for effects of stress, temperature, vibration, etc., upon magnetic quality. It attributes hysteresis to the transition of a system of molecules from one position of rest to another through an unstable condition. It explains why, even when there is no external manifestation of magnetism, magnetic metals exhibit hysteresis in their general physical properties with relation to stress, etc., and many other phenomena too numerous to discuss fully here.

Hopkinson has always been very guarded in the expression of his own views, and his work has largely consisted in laying a solid foundation experimentally for the building up of subsequent theory. The suggestions which he has made are worthy of every consideration. He ventures, as an explanation of the striking difference between the three magnetic metals and all other bodies, that ordinary temperatures exceed the critical temperatures of these bodies, and that possibly if we could obtain sufficiently low temperatures many other bodies might exhibit polarity. If this be so, another question receives additional weight—viz., Why has temperature such an enormous influence on the magnetic properties of bodies?

A careful analysis of the above theories brings us to the conclusion that we are at present quite ignorant of the essential nature of magnetism. A knowledge of its physical accompaniments is quite indispensable to the formation of a true theory of its constitution, and in this respect we are presumably on the high road to the ultimate solution of the problem. It is just possible that, bearing in mind (1) the close relationship which exists between magnetic and electric phenomena, (2) the effect of magnetism on light and of light on magnetism, (3) the important part which temperature plays in the possibility of the external manifestations of magnetism, any theory which receives final acceptance may be found to introduce electricity, light, and heat as essential to the complete manifestations of magnetism.

In spite of all the advances which have recently been made in magnetism, the science may possibly still be in its infancy, and it well becomes us to review the theories of former years with all humility, and to advance and hold our present notions with all modesty and reserve, not knowing how soon these also may be proved to be inadequate, and therefore appear antiquated.

* *Phil. Trans.*, 1885.

* *Proc. Roy. Soc.*, vol. 34.
† *Phil. Trans.*, 1885.

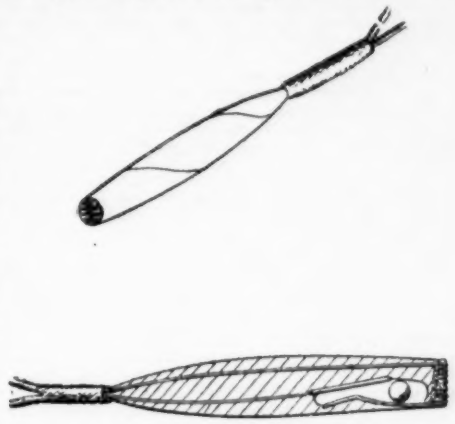
PENNY-IN-THE-SLOT ELECTRIC LIGHT.

THE "Penny-in-the-slot" electric railway light comes as a boon and a blessing to travelers in the old country. The lamps are placed in convenient positions to throw a good light on the book or paper; to the side of the car is attached a box containing the accumulator and mechanism for switching the current on and off. By dropping a penny into the slot the light is set going for fifteen minutes, at the end of which time the circuit is automatically opened and the light extinguished. Eight cents an hour is rather a dear price to pay for light, but not everybody wants to read all the time while traveling, and if one wants to read very badly, then the necessary light is cheap at any price.

ELECTRIC CIGAR LIGHTER.

THE device shown herewith is an electric cigar lighter, designed, says the *Western Electrician*, to be automatically thrown into circuit, and thus become incandescent when turned to the proper position for applying it to furnish light to the end of a cigar.

The operative parts of the lighter are inclosed in an

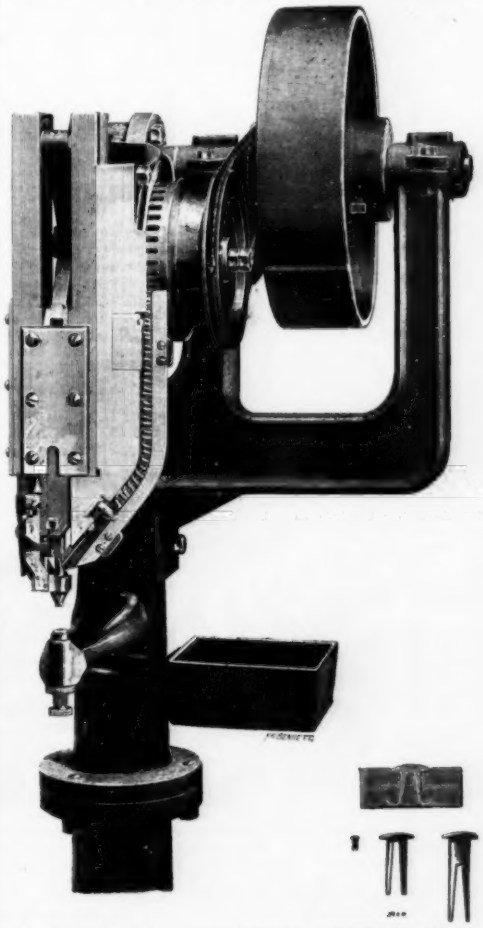


ELECTRIC CIGAR LIGHTER.

outer casing formed in the shape and about the size of an ordinary cigar. This casing consists of a shield of wood covered with binding paper or cloth, so as to imitate a cigar as closely as possible. The casing is made hollow at the enlarged end, and across it extends a wire of platinum shaped as shown. The wire is partially surrounded and backed up by a filling of asbestos fiber. Within the casing and between conducting strips there is a metallic ball, adapted, as the casing is turned to an upright position, to roll between the strips and thus form an electrical connection, causing the current to heat the wire to incandescence. A cigar may be lighted by placing the end against the exposed surface of the wire in the same manner that a light could be obtained from another cigar. G. N. Engert, of Springfield, O., is the inventor.

RIVET INSERTING MACHINE.

BIFURCATED rivets of the form shown in the annexed illustration are an American invention, and are very widely used in the States. They are employed in the manufacture and repair of belting, in affixing buckles



MACHINE FOR INSERTING BIFURCATED RIVETS.

to overshoes, in putting together horse clothing, in uniting the parts of harness, and for many other purposes. Indeed, so beautifully are the rivets made that the smaller sizes (see engravings) are admirably adapted for the construction of delicate objects like ladies' purses, and for fixing clasps to gloves. They are all made of steel and nickeled, coppered, or otherwise treated, according to the purposes for which they are intended. It is a noticeable advantage that they do

not require any material to be removed to admit them, even when applied to leather belting. They can be driven into the solid leather, pushing it aside, and then be clinched, without any reduction of section. The points are turned over very fully, and bent back into the material, so that no sharp edges are left, while the two layers of material are bound very firmly together.

To insert and close these rivets several types of machine are made. The one illustrated is driven by power, and is suitable for heavy work, such as the manufacture of belts, for which it is widely used in America. The rivets are placed in a rotating hopper in which they roll over and over until they drop into the right attitude to be delivered down a shoot in which they sit astride of a guide. This shoot delivers them, one by one, into a die in which they are held until a plunger comes down and forces them through the material into which they are to be inserted. Below the material there is a cup-shaped anvil which turns up the points as shown in the section, and makes a secure clinch. The machine is driven by a clutch which automatically disengages itself at each revolution to allow the attendant to feed the work forward. The clutch is then put in gear again by means of a pedal. The speed of the machine is 110 revolutions per minute. It is really wonderful to note the rate at which it will sew a heavy belt with steel rivets.

There are seven different sizes of machines made, varying in strength with the size of rivet they are designed to close, and the class of work they are intended for. A single hand appliance is also made for belt menders, by which a rivet can be held while it is being driven through the leather by a hammer. Of course the hammer does not make quite such clean work as the machine, but it is satisfactory for piercing straps, while the bifurcated rivet is a distinct improvement on the old copper rivet and washer.

Both the rivets and the machines are made by the Judson L. Thomson Manufacturing Company of Waltham, Mass.—*Engineering.*

[Continued from SUPPLEMENT, No. 833, page 13313.]

THE DECORATIVE TREATMENT OF NATURAL FOLIAGE.*

By HUGH STANNUS.

Lecture IV.—Continued.

§ 32.—BORDERS.

BORDERS are (generally) functional, performing, so to speak, the duty of a wall in surrounding and fencing in the ornamentation of the Panel.

BORDER-ORNAMENTATION should, therefore, be *connected* and not fragmentary. It should be always subordinated to the panel, in beauty of composition and color; and never treated in a Pictorial manner so as to lose the surface.

FIG. 31.

The general lines of Growth should be *longitudinal*, *i. e.*, following the direction of the border. Among the artificial borders are the Vertebrate, the Undulating, and the Interlacing; and these are useful as suggestions for the general lines. Plants which have *long* stems or branches are most suitable for Borders. Sometimes the Stem is continuous, as shown in Fig. 27; but it is a better treatment to show the gradual exhaustion of the branch, as in Nature; and in this latter case to preserve the effect of *continuity* by making the second branch to commence before the first leaves off, in order that they may overlap each other.

When continuity is desired and flowers of *short* stems or bunches are used, then the introduction of a spiral ribbon, as in the noble Ghiberti Architrave (though slightly more pronounced than that), will be found useful.

The Distribution should be denser and more regular than in Panels; but it may vary in accordance with some obvious or apparent Law. On comparing the two Borders—Fig. 31 (embroidery), and Fig. 37 (printed tiles)—it will be observed that in the latter the distribution is equally dense on both edges, while the former is dense (both in quantity of foliage and in strength of color) on the inner edge, and sparse on the outer one. This is a good method of emphasizing the function by increasing the density of the Border toward the edge next to the Panel in the center.

FIG. 32.

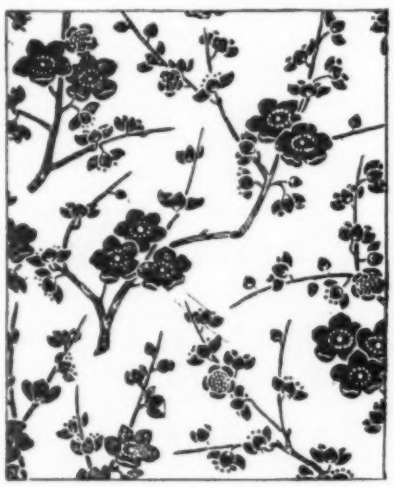


FIG. 33.

Repetition is often resorted to, and an example of this is shown in Fig. 37.

§ 33.—FRIEZES.

FRIEZES are never functional; they may, therefore, be as fragmentary, as varied in distribution, and as beautiful as the nature of the Object permits. The surface of the frieze is always *flush* with that of the Framing of the object.

The FRIEZE-ORNAMENT should preserve the sense of the Surface, and never be treated pictorially, so as to lose it; but the semi-pictorial or second degree of Realism is an appropriate treatment, and it should be rich and beautiful. The lines of growth will be generally transverse, *i. e.* upward, or oblique.

There should be no Repetition in Friezes.

§ 34.—DIAPERS.

DIAPERS are used for three principal purposes:

(i) to give a pleasing Texture, at small expenditure, in places where more important work is not necessary;

(ii) to disguise Imperfection in material, *e. g.* where the pattern hides flaws in the casting or dropped threads in the weaving, etc.;

(iii) to disguise the effect of Usage, where the variegated surface makes grease spots, etc., not so conspicuous as they would be on a plain one.

The effect of a Texture resulting from careful Distribution is therefore desirable. There are degrees in this evenness, from the dense distribution of the common Carpet to the sparse distribution of the Brocade silk. But without entering into the Textile question some expedients may be considered.

In applying Plant form to Diapers the Artist may use *separate* flowers or branches, or *continuous* stems.

SEPARATE BRANCHES may be either *isolated* or *overlapping.*

ISOLATED BRANCHES may be Powdered either in frankly severe positions, like much mediæval and heraldic work; or in (apparently) irregular positions, like much Japanese work.

FIG. 34.

SEVERE POWDERING may have the repeating branches drawn in *symmetrical* attitudes (which has, however, been deprecated in § 7), or in *balanced* attitudes, as in the design shown in Fig. 32. Here the stems and leaves are characteristically massed.

IRREGULAR POWDERING is shown in Fig. 33. Here the stems are decidedly straggling; yet they are so arranged as to occupy the space without any overlapping, and at the same time to "hide the art."

OVERLAPPING BRANCHES are resorted to when the Distribution is required to be more dense, as shown in Fig. 13. Here the leaves, etc., of one branch overlap the stem of another, and the result is a well-knit-together and well-covered design.

Each of these three is a type of a good treatment. Whichever be adopted, it should be frankly treated. Timidity is a great hindrance in Pattern work. Several of Messrs. Morris & Co.'s earlier patterns are good examples of frankness in design, *e. g.* their "Daisy" pattern of *severe powdering*, and their "Pomegranate and Lemon" of *balanced powdering.* The patterns in Figs. 34 and 15 are other examples of Overlapping Branches; and each is an admirable example of subtile arrangement. They do not show the stalk ends as the first three; but such small omissions are condoned in successful designs.

Generally speaking: Endogenous plants, or those which do not ramify, should be treated in the Separate-branch manner.

CONTINUOUS STEMS are generally undulating. The general direction of the undulating line may be vertical, *i. e.* running upward parallel with the breadth of the wall paper or textile, as in the examples. An undulating line in a general *oblique* direction running upward toward the L. H., is, however, not so conspicuous, and should be used so far as possible. The treatment, shown in Fig. 20, with *geometrical* undulating stems is to be avoided; and the subtile indeterminate curves of nature are to be sought out and used, as shown in Figs. 6 and 21.

It might be objected that all plants show Exhaustion and must come to an end, and, therefore, Continuous Stems are unnatural. The writer hesitates to condemn them, feeling that when artistically hidden the success is the test, though he would personally prefer patterns which frankly meet the difficulty by using Separate Branches, as shown in Fig. 13.

FIG. 35.

A TRELLIS EFFECT may be produced by two sets of continuous stems. This will be sparse unless there be a second plant or a second pattern to run behind and so occupy the interstices of the front or chief pattern, as shown in Fig. 16.

The Stem is too much pronounced in Figs. 6 and 21; overlapping with leaves, or a lighter tint for the stems, would reduce the conspicuousness. They are old Wall-paper patterns; and, at the time they were made, it was a common custom to "borrow" Chintz patterns for

* Lectures before the Society of Arts, London, 1891.

Wall papers or to use a design indiscriminately for either manufacture. The stem is less conspicuous and the whole surface is better covered in Fig. 11; and it is therefore a better pattern for a Diaper on a flat and extended surface like a Wall.

What has been said in the *general* rules (see § 20) about covering the stems, is of paramount importance in Diapers. Nature is here our model; the stems are generally inconspicuous in Her handiwork. In Pattern work the stems are sometimes "there to be found when looked for," but as often omitted. Many beautiful Oriental Carpet patterns show no stem whatever. The stem is often a besetting difficulty, and the student may often do without it in Diaper work; but *if* it be used, then it must be *natural*.

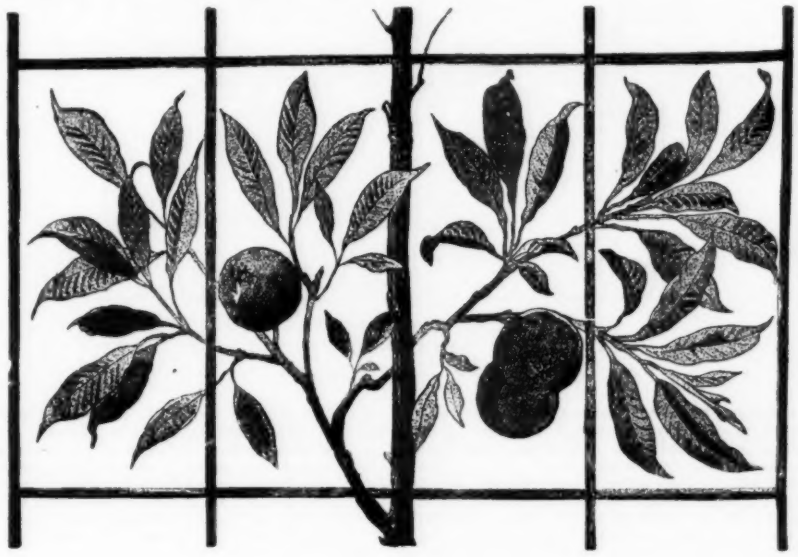


FIG. 36

Generally speaking, Exogenous plants, or those which ramify, are best, and a plant which climbs or bends much in a sinuous manner may be said to "lend itself" to this treatment.

PLANTS OF DIFFERENT KINDS may be used together in a Diaper very effectively. They should be very different in character of growth, mass, color, etc., the student being careful that they are not incongruous.

If one have a rigid stem and the other be a trailing plant, or if one be heavy like the Pomegranate, and the other small like the Olive, then a pleasingly varied pattern will result, the smaller detail occupying the interstices of the larger.

THE FLOWERS, being generally conspicuous, are sometimes difficult in Diapers. They should be so arranged in position as to avoid alignment (see § 24); and there should be a sense that they are scattered all over the ground without being in artificially arranged positions in regard to each other or to the given shape. A result of Diaper repetition is that any particular flower in each repeat will be *plumb* under and over the similar flower in the contiguous repeats of the same file, and will be *level* with the similar flowers in the juxtaposed repeats of the same rank or height. If a second flower were placed *plumb* with, or *level* with the first flower, it would certainly make vertical or horizontal alignment. Both of these are bad, the latter being the worse, and they should be avoided. Diagonal or oblique alignment, though not so objectionable, should be avoided, when possible. It will assist the Student to avoid these if he draw *vertical*, *horizontal*, and *oblique* lines through the first flowers; and then he should carefully avoid these lines in locating the other flowers.

A good method of placing the flowers is to paint a number of individual flowers, roughly, on loose pieces of paper, and cut them close round to the shapes. These loose flowers may then be moved about experimentally until the effect is satisfactory, when they may be fixed permanently in their places, and the correct working drawing made.

LARGE FLOWERS will often spoil the *balance of the diffusion* by their *size*, but this may be obviated by cutting up their mass, as it is not the *outer size* (to the extreme tips of the petals) but the *weight* which gives balance. Hence, when using large flowers the Student may reduce their weight by opening the petals and showing wide spaces of the ground between them.

It is impossible to foresee all objectionable treatments; and it would be impracticable to give diagrams illustrating them; but what has been said will, it is hoped, lead the Student to search for these lapses, and to expunge them if found.

§ 35.—TWO METHODS IN DESIGNING DIAPERS.

In designing with ARTIFICIAL FOLIAGE the artist begins with a general idea of the *composing lines*.

But in designing with NATURAL FOLIAGE, he begins by drawing a *branch of the plant*, and he does not attempt to make it follow any lines but those which God designed for it. He makes duplicate drawings of this piece or branch, and he then arranges them at the repeating distance which is prescribed by the technical necessities of the material. He fills in the gaps with more nature, if required, considering the placing of the Flowers first.

This method of composing a Diaper by the arrangement of overlapping duplicates of a study from Nature is more likely to be Natural than the method of making *lines* first, and then clothing them with leaves, etc., because:

(i.) there is no predilection or prejudice in favor of one set of lines over another, and the Student is willing to take Nature's line;
(ii.) the result will be *masses* of foliage rather than *lines* of stems.

§ 36.—INDEFINITE SHAPES AND FORMS.

INDEFINITE SHAPES and FORMS and also those of Irregular or extreme proportion may be easily decorated with natural foliage when the more intractable lines of artificial foliage could not be applied. An example is given in the perforated panel shown at Fig. 35, in which the foliage pleasingly occupies the spaces around the Initial letter, and gives Connectedness to the Frame without loss of Clearness.

FIG. 37.

BODY-ORNAMENTATION is often composed of plant-form with good effect, as may be seen in some beautiful classic Drinking-cups, Bronze-vases, Cinerary-urns, Column-shafts, etc., in various Museums; and on many beautiful Keramic works seen at Exhibitions. This branch of the subject is, however, more properly dealt with under the head of Vase-decoration.

FREE ORNAMENTS are often composed of plant-form with good effect. In interior decoration natural foliage is often used as a central "Trophy" in a panel, or frieze, or as a cresting Acroterion over a Frame or Cornice, or in combination with a Shield or Tablet encrusted on Mouldings, etc.

The *absence* of any strongly marked or geometrical curvature which might attract the eye and militate against the architectural lines, the *mass* of leafage which is possible with certain plants, and the *elasticity* with which the stems may be bent to fill odd corners, render natural foliage very valuable; hence its frequent use.

§ 37.—ACCESSORY OBJECTS.

ACCESSORY OBJECTS are occasionally used in connection with natural foliage; for the purpose of giving Logical-commencement, Mass, Line, Color, Continuity, Distribution, or Contrast.

VASES are useful in Panels. The position, at the bottom of panel, holding the branches gives a Reason for their attitudes, and the Mass is placed where it is most needed. It affords an opportunity for the introduction of any desired color; and in a succession of panels with different foliage in each, the similarity of the containing vases gives Unity of effect.

RIBBON is useful in Panels. It ties the branches, and gives the Logical commencement, as shown in Fig. 5. The lines of the ribbon are often useful for Flow-of-line, and for contrast to those of the foliage. It gives opportunity for Color, and thus for Unity. It is also useful in Borders, to give Unity, and Continuity; as is seen in the Ghiberti architrave. The use of Ribbon, in connection with natural foliage, by the artists of the Quattro and Cinque Cento is well worthy of study by the student; but it would require an entire Lecture; and hence must be passed over for the present.

TABLETS for inscriptions, and Symbols of various kinds, are used in connection with natural foliage: this, however, belongs to the Didactic branch of the subject.

§ 38.—ANIMALS.

ANIMALS are occasionally used in connection with natural foliage, for the purpose of giving Interest, Color or Distribution.

FIG. 38.

SMALL BIRDS and BUTTERFLIES are those that are generally used; and they are applied in Panels only. Their value, in giving points of color and in occupying spaces of the ground which might otherwise appear vacant, will be seen on referring to Fig. 30. The Artist will, of course, introduce those only that frequent the particular plants which are shown.

§ 39.—VALUE OF NATURAL FOLIAGE.

The study of Natural foliage will enable the Artist to ignore the Historic styles (except as scientific Archæology). These "styles" are so many *ruts* worn by the wheels of our predecessors; but the critic, of the schoolmaster persuasion, would treat them as if *Moats* from which he, like the Kentaurs in the 7th circle of the Inferno, would rebuke any tendency to rise higher.

The *primary* use of Plant form, *i. e.*, as Natural Foliage, has been the attempt of the writer on this occasion: the *secondary* use, *i. e.*, as contributory to the building-up of Artificial Foliage (the so-called "Acanthus"), will be dealt with on another. Then, it will be seen that it will enrich it and revivify it from age to age.

It may always be used, as an intermediate feature or "modulating chord," between the Architectural and Pictorial Arts.

It is (when properly treated) the only kind of ornamentation that is permanently pleasing or has been used in all times and places. An instance of its suitability is seen at South Kensington Museum in the borders round the two fine pictures by the President of the Royal Academy. One of these is Greek in *place*, and the V. century B. C. in *date:* the companion is Italian in *place*, and the XIV. century A. D. in *date*. To both of these subjects, so wide apart, no one artificial ornamental pattern (which would necessarily belong to one place and date) could be suitable; but the natural foliage which belongs to *all* countries and times was suggested by the writer, who had the honor of carrying it out.

§ 40.—ON RULES, ETC.

The writer does not wish to dogmatize on the subject. The Rules which have been given are the results of some experience, but they are only Grammar. There is a grammar of Graphic Representation in all Arts, in which minute rules are laid down for the guidance of Students; but there is also an enlarged grammar, of Inspired Expression, in each, which the Masters lay down for themselves.

Rules, as Mr. J. W. Papworth observed, are like the Buoys round shoaly coasts, which may be ignored

when the Mariner has learnt to sound the bottom for himself. The Masters in the Arts may appear to ignore rules and produce thereby picturesque Language, picturesque Music, picturesque Architecture, or picturesque Decoration; they are great by reason, not of the broken rules, but of the Power that is above rules. The Student is therefore advised, not to commence by striving to be picturesque (probably in this he would be only copying the faults of another), but to choose good grammar and simplicity, and in time, if he have it in him, Originality will be added unto them.

The Rules should not be too apparent; the student must hide his Art. The Spectator should see Natural foliage, and should feel that it decorates the space. (Note that "*see*" is used in the former case, and "*feel*" in the latter; for he should only have an impression that the whole appears decorous; but the means wherby it has been made so, *i. e.*, the Art, should be hidden.) "Ars est celare Artem;" and if the work appear too artificial, then has the worker failed.

§ 41.

Among those who are known as producing good work in this branch of Applied Art are: Miss Louisa Aumonier, Professor George Aitchison, A.R.A., Messrs. Arthur Brophy, Charles Campbell, Walter Crane, R. I., Louis Davis, Owen Davis, Lewis Day, Dr. Christopher Dresser, Miss Kate Falkener, Messrs. George Haite, Edward Hammond, Thomas Hay, Miss Florence Lewis, Messrs. Fredrick Miller, William Morris, M.A., William Muckley, George Robinson, F.S.A., Arthur Silver, and Charles Voysey.

§ 42.

The examples have, so far as possible, been taken from Wall papers rather than from Textile diapers; because the *paper* surface is better for photographic reproduction than the woven one. Acknowledgment is due to the following for the original work reproduced in the figures as mentioned: Miss Cole, at South Kensington, Fig. 13; Miss E. S. Moore, at S. K., Fig. 31; Miss Lambert, at S. K., Fig. 37; Mr. Selwyn Image, per School of Art Needlework, Fig. 32; Messrs. Campbell and Smith, Figs. 30, 36; Messrs. Jeffrey & Co., Figs. 33, 34; Messrs. Morris & Co., Fig. 15; Messrs. Toleman, Fig. 16; Messrs. William Woollams & Co., Figs. 6, 11, 12, 17, 21.—*Jour. of Soc. of Arts.*

THE MOUNT BLANC OBSERVATORY.

IN a previous number we announced that Mr. Janssen had communicated to the Academy of Sciences the results of the work done by him this year at the summit of Mount Blanc, for the study necessary for the execution of his important undertaking. This interesting memoir we produce *in extenso:*

"I think that the Academy will receive with interest some account of the work undertaken on Mount Blanc with a view to erecting thereon an observatory designed principally for the study of physical astronomy. In a communication of July 12, 1891, I informed the Academy of our project of proceeding, near the summit of the mountain, to a series of borings in order to determine the thickness of the crust of snow that covers the rock, and to obtain some information as to the importance of the foundation necessary for the establishment of the structure.

"These labors were begun last August. Mr. Eiffel was kind enough to take them in charge, and appointed Mr. Imfeld, a distinguished Swiss engineer, to see to their execution. The summit of the Chamouny side was attacked at about twelve meters in vertical distance, and a shaft was sunk horizontally, running from north to south, and which reached a length of about twenty-three meters (Fig. 1). At this moment the end of the shaft nearly corresponded to the summit of Mount Blanc. The snow was found to become harder and harder, but was not converted into true ice.

"In order to assure the safety of our workmen, Mr. Eiffel and I judged it prudent to place at the entrance of the shaft a hut buried in the snow and forming an adit gate (Figs. 1 and 2). This hut afforded shelter to the men in bad weather and protected the tunnel against the entrance of snow. Besides it gives us information as to the movements of the snow toward the summit.

"These labors occupied a large part of the month of August. They were unfortunately interfered with by bad weather. Then Mr. Imfeld, called home by urgent business, asked my permission to quit the work, and I assumed the direction of it.

"I have said that at the time Mr. Imfeld left Chamouny the end of the shaft had reached the vertical of the east summit of Mount Blanc, which is very narrow in the north-south direction, but very elongated in the direction from east to west. We had always intended, as soon as the shaft had reached the vertical of the summit, to drive lateral shafts from east to west. It was in this direction, in fact, that there were most chances of finding the tops of the rocks (if any existed) that rose to the slight height of 12 meters from the surface.

"The new shaft that I sunk was therefore directed from east to west, with an inclination toward the side that faces Italy, and on which are exhibited the rocks nearest the summit. Like the first shaft, it was 23 meters in length, and the two together were therefore 46 meters in extent. No rock was met with in the line of these shafts; but there is nothing in this that should surprise us, when we reflect that the summit of Mount Blanc is a hundred meters in length, and that a shaft one meter in width has many chances of passing between two needles. Besides, it is quite possible that the icy crust covering the aggregation of needles that according to all probability forms the head of Mount Blanc is more than twelve meters in thickness. So, while pursuing this search for the rocks on the summit (a search that will have to be continued), I thought at the same time of a solution of the question under entirely new conditions. I do not, in fact, regard the establishment of a structure founded upon the hard and permanent snow that forms the summit of Mount Blanc as impossible. But it is evident that a structure built under conditions so novel must be able to satisfy quite peculiar exigencies. It is necessary in the first place to anticipate motions in the icy crust that forms the summit, and which may take place either in a vertical or lateral direction. A structure placed under such conditions will have to be provided with special arrangements that will permit of obtaining rectifying displacements, designed to cause it to resume its original and normal position should it happen to be moved therefrom. I have already studied the question, and, without entering here into details, I shall say that I have assured myself, by studies of the resistance of the hardened snow, that rigid platforms placed under the structure, and against which bear screws forming jacks, would offer a resistance far exceeding 3,000 kilogrammes per square meter—a resistance much greater than is necessary to raise again a structure of this kind. The edifice having been raised again, one would ram snow into the vacant space formed, the jacks would be raised and everything would be ready for a new operation. By analogous means, it would be possible to obtain lateral motions by forming, of course, a trench in the snow on the side toward which it was desired to move. It is evident that a structure of this kind should have all its parts so connected that it may, without danger to itself, undergo those general displacements necessary to be anticipated here.

"Besides, in order to permit it to withstand the violent winds that sometimes prevail upon Mount Blanc, it would be indispensable to sink it deeply in the icy crust. Such a result would be obtained by giving it two stories, the lower of which, and even a portion of the upper, would be situated beneath the level of the snow. The rooms in the lower story, lighted by thick

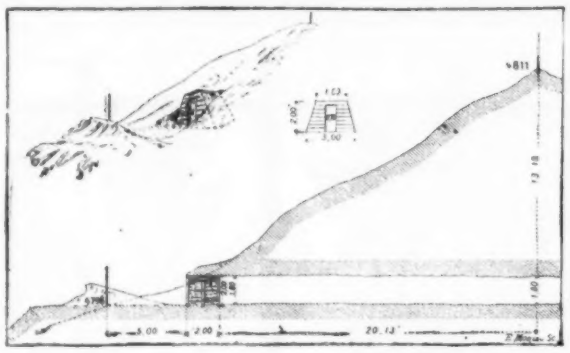


FIG. 1.—EXPLORING SHAFT AT THE SUMMIT OF MT. BLANC, WITH DETAILS OF HUT CONSTRUCTED AT THE ENTRANCE.

FIG. 4.—VIEW OF MOUNT BLANC, FROM A PHOTOGRAPH TAKEN AT THE SUMMIT OF THE BREVENT BY MR. TAIRRAZ.

1. Location of Mr. Janssen's structure at the summit of Mount Blanc. 2. Rocks of the Petits-Mulets. 3. Grand-Rocher-Rouge. 4. Regions in the vicinity of Mr. Vaillot's observatory. 5. Inn of the Grands-Mulets. 6. Glacier opposite the new shelter constructed by the French Alpine Club near the Inn of the Grands-Mulets.

plates of glass, would serve as dormitories, storerooms, etc. Provided with double walls, they would be very habitable and much less exposed than the upper rooms to the action of inclement weather. Such are the general lines of the project that I propose. In order to proceed at once in the direction indicated, I was

FIG. 2.—HUT CONSTRUCTED AT THE ENTRANCE OF THE EXPLORING SHAFT.

desirous of erecting, this year, on the summit of Mount Blanc, a small structure designed to pass the winter in, and to inform us as to the motions with which we should have to contend; but the season was already advanced, and the general opinion was that the time for work upon the summit had passed. However, on pointing out the interest of this little enterprise to my workmen, I persuaded them to attempt it.

"We rapidly constructed a little hut, and, happily favored by fine autumn weather, were enabled to erect it (Fig. 3). It is provided at the corners with joists that are prolonged into the snow and are connected with a strong frame of thick planks, upon

FIG. 3.—WOODEN STRUCTURE ERECTED ON THE SUMMIT OF MOUNT BLANC, AT AN ALTITUDE OF 4,811 METERS.

which snow is rammed in order to allow a strong icy block to share in its stability. Before my departure from Chamouny, the structure had been in place for twenty days, and nothing indicated that it had undergone any sensible displacement. I made arrangements to receive news from it from time to time.

"Next year I intend to place a larger structure on the summit, through which I hope it will be possible to give an account of the elements of the problem and to begin observations.

"I desire to state here that these works have happily cost the life of no one, and that our workmen have all kept in good health. There is unfortunately one very regrettable death to be mentioned, that of Dr. Jacottet, who was much beloved at Chamouny, and who was full of promise. Dr. Jacottet asked Mr. Imfield to allow him to accompany him in one of his ascents, being very desirous of going to the summit, which he had wished to see for a long time.

"It is there, it appears, that he contracted the disease that carried him off. He was not attached to the expedition.

"In conclusion, I desire to thank Mr. Eiffel, the great engineer, for his generous co-operation, as well as those who were under his orders, and also Mr. Vallot, who placed his observatory cottage at Bosses at the dispoal of our workmen, and, finally, these latter themselves (among whom I take pleasure in distinguishing Mr. Frederick Payot) for their courageous perseverance. J. JANSSEN."

We add to the above memoir a few engravings that form a complement thereto.—*La Nature.*

THE VICTORIA CATARACTS.

THE Niagara Falls have acquired such a celebrity that one's thoughts immediately and almost exclusively revert to them when it is a question of those grand spectacles of nature called cataracts. There are others, however, which equal them, and which are not spoken of, doubtless because access to them is more difficult or because the country in which they are situated is wilder. Those of which we herewith give views, and which are formed by the Rio Yguazu, amid the virgin forests of Brazil, belong to this catagory. A young Swiss physician, Dr. Francois Machon, now established in the Argentine Republic, has recently visited them in company with Mr. Ferrara Dentice, and the information that he has communicated to us upon this subject will prove of so much the more interest to our readers in that it possesses all the charm of novelty and that we are the first to publish it.

"The Rio Yguazu is formed by the numerous water courses which come, on the one hand, from the Sierra des Missions, and on the other from the Santa Catharina and Sao Paulo Mountains. At its origin, near Paranagua, it is separated from the Atlantic Ocean only by the Sierra del Mar. Thence, as far as to its mouth in the upper Parana, the river follows a nearly invariable direction from east to west and receives numerous affluents, and, among others, the San Antonio, starting from which it serves as a boundary between the two republics—the Argentine and Brazil. Afterward, having traversed the series of rapids, it crosses the Sierra de la Victoria and is precipitated from a height of 196 feet into the great lateral fault of the Parana.

"Above the rapids of the mouth of the San Antonio the Yguazu is navigable and provided with steamboats. Above the Victoria cataracts its waters extend to the right and left and form a sort of lake whose overflow gives rise to a series of falls of which we present some views. This lake is surrounded by dense virgin forests and presents a series of rocky islets covered with verdure. We made a three days' excursion on it, of which we give a summary.

"Starting from the Brazilian military colony on the 10th of July, 1891, we abandoned ourselves to the current and soon reached the mouth of the Yguazu. We traveled in an Indian canoe hollowed out of a trunk of cedar and measuring 28 feet in length by 20 inches in width. We had two Brazilian guides and carried material for camping out and provisions enough to last three days. It is necessary to have sailed in such a boat to appreciate the impression of fear that one feels therein the first time. Seated in the bottom of the fragile dug-out, the hands resting upon the upper edges of its sides, with the tips of the fingers dipping in the water, one instinctively endeavors to maintain his equilibrium, which the motions of the boatmen threaten to destroy at every instant. These men, standing upright, and using the paddle or the 'botador' (boat hook), direct the boat without uttering a word and without their cadenced motions in any way breaking the silence of the solitary shores.

"In the first part of its stretch the river is relatively calm, but we soon see its shores approaching each other, the current becomes stronger and the navigation more difficult, and it is not long before we find in the middle a series of rapids that we shoot with great trouble.

"It is now that we can admire the dexterity and calmness of our boatmen, from whom the prespiration stands out in great beads and who nevertheless take breath only to dry the bottom of the boat. The man in front, the botador in hand, is several times obliged to jump upon a rock in order to draw the boat toward him by means of a rope, while his companion and we endeavor to give it an impulsion.

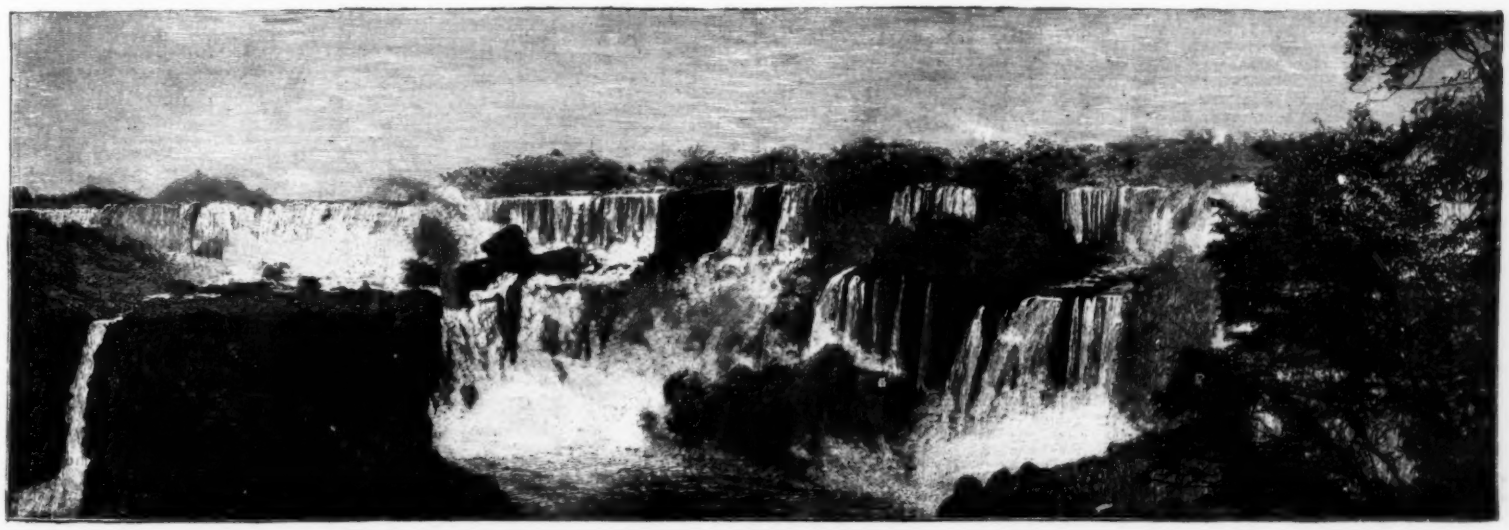
"The next day we gave up navigation, and it was then that it was necessary for us to open up a path for ourselves amid a gigantic heap of rocks. After an hour of climbing, we gave a loud hurrah, a cry of joy and admiration. It was the Brazilian portion of the cataracts, the Salto Santa Amalia, with its column of mist, that we perceived in the distance between the perpendicular walls of rock. To its right, on a nearer plane, a few white trails indicated the accessory falls of the Argentine bank.

"After this, in measure as we advanced, it was nothing but enchantment. After a widening of the river which produces upon each shore a sort of gulf, comes the summit of the promontory of Esperance. The cliffs that dominate the current of the Yguazu approach each other, and the masses of rock that we climbed were enormous. We came opposite the first fall of water belonging to the cataracts and which is called the Salto de l'Alegria. This falls from a height of about ninety-feet upon a pile of rocks, at the center of which it rebounds. A second small fall, the Salto Santa Margarita, descends from shelf to shelf, and, further off, we see the Salto de Cajon divided into two parts by a rock which is bare at its base and crowned with a lovely thicket of bamboos.

"Following these three falls is a wall of rock that descends into the current. This terminates in a sort of spur which would merit the name of the promontory of Surprise.

"Up to here we had not ceased to wonder; paralyzed by emotion, we suddenly stopped. The Salto Santa Maria, that is to say, all the Argentine portion of the cataracts of the Yguazu, had just burst upon our sight. A rock covered with verdure appeared to us then under the form of an island (Isla Central) flanked at its right by another and smaller rock standing opposite the promontory of Surprise, with which it is connected by the immense hemicycle of the falls of the Salto Santa Maria. Three gigantic strata divide the latter into three shelves, the lower and largest of which exhibits three other rocks that might be taken for fortresses. The two upper shelves are divided in their turn by a dozen rocks into a series of different currents which afterward mingle, and from which arise clouds of mist. The height of the Salto Santa Maria is 196 feet.

"Bending our gaze toward the Salto Santa Amalia, we endeavored to approach it, and followed the wall of rock as far as to the height of the central island, which opposed an insurmountable barrier to us. Despite our efforts, we succeeded in seeing only a portion of it. An entire by-corner was hidden from us by the perpendicular cliff and the column of mist, which rose to seek the clouds. Near the central rock, the Yguazu precipitates itself in a single stream from a height of 190 feet. From the immense rent to the bottom of which the entire river is precipitated, the water of the latter flows through a channel situated between the promontory of Surprise and the place



THE VICTORIA CATARACTS, BRAZIL.

whence, wet by the spray from the cataract, we contemplated the hemicycle of the Salto Santa Maria.

"Let us say in conclusion that the 'Saltos' as a whole delineate a gigantic three of more than two miles in extent. Adding also thereto the accessory falls of each shore, we see that the curve that measures the greatest length of the sheet of water represents a length of from 2¾ to 3 miles."—*L'Illustration.*

FOSSIL BIRDS IN THE BRITISH MUSEUM.*

IT is always a matter of extreme interest to trace back any group of beings to their first recorded appearance in geological history, and the task becomes the more attractive in proportion to the rarity of the organism sought for.

The fossil remains of birds, which form the subject of Mr. Lydekker's catalogue, constitute nearly the smallest group of vertebrate fossils known; indeed, it is only within the last thirty-five years that any considerable number of species had been recorded.

That the existence of birds at the period of the Secondary rocks should have been first intimated by their

FIG. 1.—Right lateral aspect of the skull of *Archæopteryx macrura*, Owen, from the lithographic stone, Lower Kimmeridgian, Solenhofen, Bavaria (½). (After Dames, "Palaeontologische Abhandlungen," vol. ii., 1884.)

footprints may seem strange; but as far back as 1835 a notice appeared in *Silliman's American Journal of Science* stating that Dr. Deane had discovered *impressions resembling the feet of birds* upon some slabs of Triassic sandstone from Connecticut. Dr. Hitchcock, who was the first to submit these tracks to careful scientific examination, concluded that they had been produced by the feet of birds which must have been at least four times larger than an ostrich. The great size of some of these footprints, however, presented at the time an obstacle to their acceptance, notwithstanding the fact of their exhibiting the same characteristic number of toe joints as exist in the feet of living tridactylous birds—namely, three phalangeal bones for the inner toe, four for the middle, and five for the outer one.

The subsequent discovery of the entire skeletons of great wingless birds in New Zealand has to some extent destroyed the force of this objection as to their size; nevertheless it seems more probable that these impressions were made by some of those gigantic Dinosaurs whose remains have been in later years met with in such abundance in the Secondary rocks of the American continent, many of which were bipedal in their method of progression, their fore limbs being exceedingly short, and but ill adapted for use in walking.

The hind foot in *Iguanodon* and in some others was tridactylous, and agreed in the number of toe bones with the foot of the *Dinornis* and other flightless birds. But between the discovery of the reputed footprints of birds in the Connecticut Valley sandstones and the finding of true bird remains in Secondary rocks, a long interval of time has elapsed. Some supposed bird bones from the chalk of Burham, near Maidstone, were figured and described as long ago as 1845 by Dr. Bowerbank, under the name of *Cimoliornis*, but these proved to belong to a gigantic Pterodactyle, and not to an albatross. The same fate befell Dr. Mantell's Wealden bird (*Palæornis cliftii*, 1844), now also transferred to the Ornithosauria by Mr. Lydekker.

Passing over so many fragmentary remains, discovered in 1858 by Mr. Lucas Barrett in the Greensand of Cambridge, referred to birds, we come in 1861 to the discovery, announced by Dr. H. Von Meyer, of the impression of a single feather upon a slab of lithographic stone from Solenhofen, Bavaria, followed in 1862 by the description by Prof. Owen of the skeleton of a remarkable long-tailed bird from the same formation and locality, the *Archæopteryx macrura*. This, which is still the earliest known avian fossil, is also the most generalized bird known; and the discovery, twenty years later, of a second example only serves to confirm the correctness of the conclusions which had been arrived at from a study of the first found example.

That it was clothed in feathers serves to prove the true avian character of the fossil, no reptile having been met with possessed of such epidermal structures. The remarkable features are that the jaws were armed with conical enameled teeth implanted in distinct alveoli (see Fig. 1); the three metacarpals in the manus are separate and the phalanges are free (not anchylosed, as in modern birds), and each of the three digits was armed with a terminal claw; the centra of the vertebræ are amphicœlous; there are twenty free vertebræ in the tail, which is longer than the body, each vertebra bearing a pair of feathers, and the tail does not terminate in a pygostyle, like most modern birds. From these, and other anatomical characters, *Archæopteryx* has been placed in a distinct order, the Saururæ, or lizard-tailed birds.

The next important bird discoveries from the Secondary rocks were those made in North America by Prof. O. C. Marsh, in 1870, from the Upper Cretaceous strata of Kansas, U. S., by which we became acquainted with two most distinct and important types, the *Hesperornis* and the *Ichthyornis*. Both of these birds are remarkable as having their jaws armed with teeth. The former (*Hesperornis*) had the teeth implanted in grooves, it had only rudimentary wings, a flat keelless sternum, and saddle-shaped vertebræ. It was a huge fish-eating diver, nearly 6 feet high, probably resembling in appearance the loons and grebes (see Fig 2).

The latter (*Ichthyornis*) was a bird of powerful flight, having well developed wings and a strongly keeled sternum; its jaws were armed with teeth in distinct sockets, and the vertebræ were biconcave (see Fig. 3). By far the greater proportion of avian remains known are of Tertiary age; many are referable to existing birds, but a few of them are of almost as great interest to the ornithologist as those already referred to, either as representing, like them, extinct forms, or because they tell of important changes during Tertiary times in the geographical distribution of many genera of birds. The oldest of these remains have been obtained from the London clay. A single skull of a large ostrich-like bird was obtained from the Lower Eocene of the Isle of Sheppey, and described by Owen in 1869 under the name of *Dasornis londiniensis*. Two limb bones of a bird as large as an ostrich, but more robust, and with affinities to the Anserine type, as well as to the Ratitæ, were obtained about six years ago from the Lower Eocene near Croydon, and described by Mr. Newton under the name of *Gastornis klaasseni*. Two other species of *Gastornis* had previously been described from the Eocene of Meudon and Rheims, in France, so that the Ratitæ were doubtless well represented in Western Europe in Tertiary times.

Another remarkable discovery in the London clay of Sheppey is that of the *Odontopteryx toliapicus*, a bird with a powerfully serrated bill, well adapted for seizing fish, which probably formed its prey.

The interest attaching to the discovery, fifty years ago, of the bones of extinct ostrich-like birds in New

FIG. 4.—Restored skeleton of *Dinornis* (*Pachyornis*) *elephantopus*, Owen, from Pleistocene deposits, Oamaru Point, South Island, New Zealand (about ⅛ natural size). (Original in British Museum, N. H.)

Zealand remains unabated; their former abundance may be imagined from the fact that there is hardly a museum in the world where remains of the "moa" are not to be found, and they still continue to be sent to Europe for sale. The series of skeletons of *Dinornis* set up in the Vienna Museum is even finer than that in the British Museum. In the latter, six almost complete skeletons may be seen, besides an immense series of detached bones (see Fig. 4). The tallest skeleton is probably 10 ft. and the smallest 4 ft. in height. Specimens showing the skin and feathers still attached to the bones are also preserved, evidencing the comparatively modern date at which they were exterminated.

Another island which possessed a now extinct flightless bird is Madagascar. Bones and eggs of this great bird, the *Æpyornis*, which probably rivaled the *Dinornis* in size, are preserved in the British Museum;

FIG. 2.—Restored skeleton of *Hesperornis regalis*, Marsh (1870), from the Cretaceous of Kansas, North America (about ⅛ natural size). (Reproduced by permission, from Prof. O. C. Marsh's "Extinct Toothed Birds of North America" (folio), New Haven, Conn., U. S., 1880.)

FIG. 3.—Restored skeleton of *Ichthyornis victor*, Marsh (1872), from the Cretaceous of Kansas (⅛ natural size). (Reproduced, by permission, from Prof. Marsh's "Extinct Toothed Birds of North America" (folio), New Haven, Conn., U. S., 1880.)

* "Catalogue of the Fossil Birds in the British Museum (Natural History), Cromwell Road, S. W." By Richard Lydekker, B.A., F.G.S., F.Z.S. Pp. xxviii. and 368. (London: Printed by Order of the Trustees, Longmans & Co.; B. Quaritch; Asher & Co.; Kegan Paul & Co., 1891.)

but, owing to the lack of exploration in the island, we know as yet of only a few odd bones, where entire skeletons doubtless exist, perhaps as abundantly as in New Zealand. The egg of *Æpyornis* is the largest bird's egg known, its liquid contents being rather more than two gallons.

The close affinity existing between birds and reptiles has long ago been an accepted fact in zoology; the finding, therefore, of such primitive birds as *Archæopteryx*, *Hesperornis*, and *Ichthyornis* on the one hand, and of the numerous bird-like Dinosaurs in Europe and America on the other—indeed, the whole tendency of this branch of modern paleontological discovery—has been to strengthen the relationship of the two, and to confirm their association in one primary group of the Vertebrata, the Sauropsida.

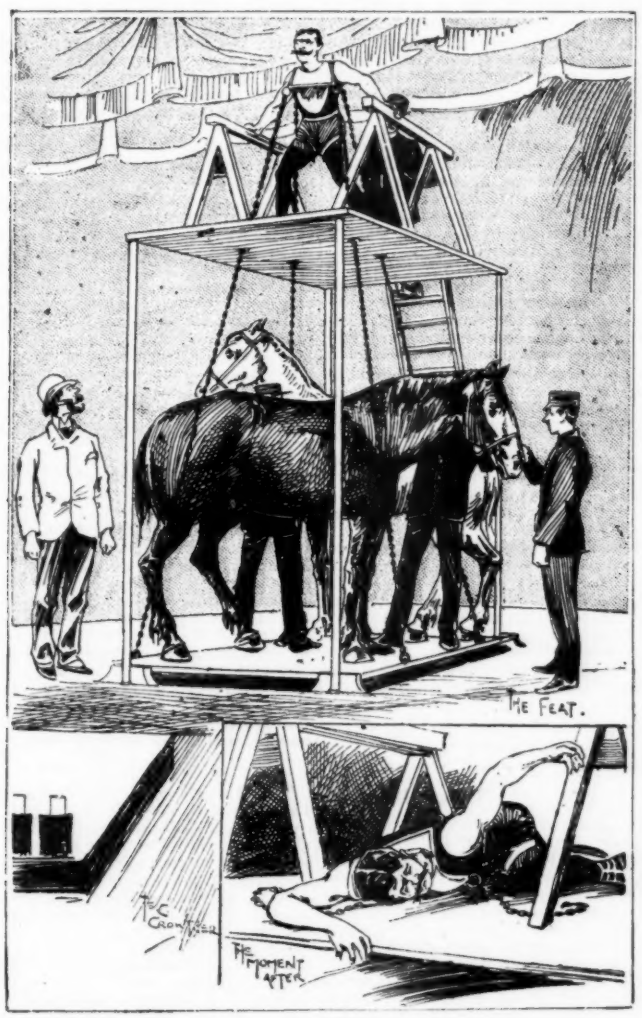
One very interesting point we may note with regard to the class Aves—namely, that while birds still possessed the teeth which they had inherited from their reptilian ancestors, two very remarkable and distinct types of the class had already made their appearance, and that these two types have persisted on, even to the present day, dividing the class into *Ratitæ* and *Carinatæ*. The characters of the ancient toothed birds indicate undoubtedly a great antiquity for the class, which was probably evolved from the Reptilia in Triassic times or even earlier.

Although the majority of entries in Mr. Lydekker's catalogue relate to the *Carinatæ*, the *Ratitæ* are also well represented in the collection, and there is a sufficient number of remarkable extinct forms and figured types to impart to this volume a high scientific interest.—*Nature*.

THE STRONGEST MAN ON EARTH.

SAMPSON, the "strong man," who is exhibiting his powers at the Westminster Aquarium, London, has lately accomplished the feat of lifting a load of over a ton and one-half. Two horses, two men, and a platform were the component parts of a weight of 3,800 lb. which Sampson raised after he had gone through a familiar exhibition of his bar-lifting and chain-breaking capabilities. The special apparatus required for the feat was formed of four uprights, high enough to admit the horses and men beneath a platform, on which Sampson stood. From the ends of a leather collar round his neck depended iron chains, which were attached in turn to a movable platform below, made to slide vertically on wheels. One horse, a bay, weighed 1,450 lb., and stood 16 hands 3 inches high; the other, a gray, weighed 1,375 lb., and stood 16 hands 2 inches; the men weighed 12 stone 9 lb. and 11 stone 13 lb. respectively, and the platform 600 lb.

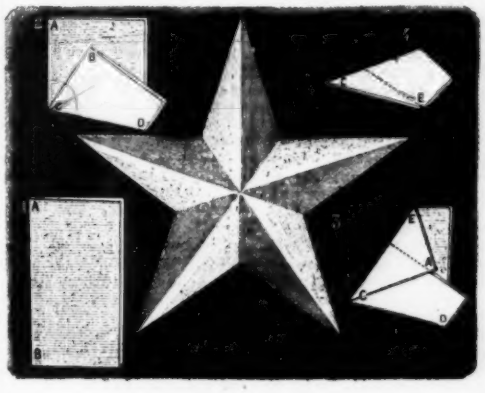
A committee watched the performance, which was also keenly scrutinized by the audience. Among these was the redoubtable Sandow. Mounting the upper platform by means of a ladder, and placing the collar round his neck, Sampson braced himself for the feat, amid breathless silence. To accomplish it appeared beyond even his powers. His form, in proportion to the enormous weight in the huge structure beneath him, seemed absurdly inadequate. "Keep the horses quiet!" he sang out. "Ready!" He bent to the task, and strained till his veins seemed about to burst. Then the platform was seen to move slightly, but only slightly. Sampson tried again—and failed. Begging for a short rest, he made a third attempt after a few seconds' interval, and, following a supreme effort, the gigantic load was seen to move to a height of at least three inches. The platform fell with a resounding crash that was drowned in the deafening applause. It was a hardly-won triumph, though. Sampson fell forward with a gasp and groan, and lay prostrate for several seconds afterward.—*London Daily Graphic*.



LIFTING TWO HORSES AND TWO MEN.

TO CUT A FIVE-POINTED STAR FROM PAPER WITH A SINGLE CLIP OF THE SCISSORS.

TAKE a double sheet of letter paper and place the fold A B (Fig. 1) to the left. Fold it according to the line C D (Fig. 2), so that the angle A C B shall be



half of the angle B C D. This may be quickly accomplished by tentatives, in folding the sheet again according to the line C E, which is merely the line C B of Fig. 2 prolonged. The sheet will then have the aspect represented in Fig. 3. Now fold it in two, according to C A. If the line C E comes upon C D, it will be due to the fact that the first folding of Fig. 2 has been well executed, but if it falls inside or outside, it will be necessary to modify the first fold C D. When it is found that the coincidence is perfect and that the line C E falls exactly upon C D (as shown in Fig. 4), cut the paper with the scissors according to the straight dotted line, and, upon unfolding it, it will be found that there has been formed a pretty five-pointed star, such as is shown in the center of the engraving.

Our fair readers will find this a simple and rapid method of cutting stars from gilt paper for the decoration of Christmas trees.—*L'Illustration*.

THE PURIFICATION OF WATER.*

By ALBERT R. LEEDS.

COMPARING the composition of the waters obtained on the 2d of May, at noon, from the Genesee River, at Elmwood Avenue bridge, and that from the conduit at Mount Hope reservoir, Professor Leeds stated that the water from the Genesee River had a slight yellow color, due to peaty matters in solution, and was slightly turbid. It had a flat taste and a slight odor. That from the Mount Hope reservoir was colorless, but manifested a whitish turbidity; it was pleasant to the taste, and had no odor. The Genesee water contained 0·044 of a grain of free ammonia per gallon; the Hemlock, 0·082. The Genesee water contained of albuminoid ammonia, with organic nitrogen, 0·071 of a grain; the Hemlock, 0·078; slightly more. The Genesee water required to oxidize the organic matter, 0·147 of a grain of oxygen; the Hemlock Lake, 0·136 of a grain, or something less. The difference was due to these peaty organic matters in solution, which require a slightly greater amount of oxygen to oxidize them. The hardness of the Genesee water was 6·85 grains; the Hemlock Lake, 3·3. The total solids in solution in the Genesee water were 16·47 grains; in the Hemlock Lake, 5·08 grains. A count of the bacteria contained in the waters showed that there was in the Genesee River water 112 colonies of bacteria to the cubic centimeter; in the Hemlock Lake, 63 colonies. The samples were sent to me in jugs labeled 1 and 2, and at the time of making the analysis I did not know to which samples the numbers referred. The analysis showed that No. 1, the harder water, of course, came from the river. And I shall now label these bottles containing a portion of that water. And, in the first place, there is the Genesee water. Mr. President, you will notice this limpid matter in it. Perhaps you can see it.

After making the analysis, for reasons which I will explain presently, I added to each water a grain of sulphate of alumina, and then filtered the samples through sand. This marked No. 1 is the filtered Genesee water; 2, the filtered Hemlock. I do not think that it is possible to notice any difference. Both of those samples are as entirely limpid, entirely colorless, as the purest distilled water that I could make in my laboratory. They are absolutely devoid of any color and any odor. The whitish opalescence, or the whitish turbidity, has been removed from the Hemlock water; the yellow, from the Genesee water.

This brings me to the treatment of waters by filtration. And at the outset I would like to say that I know of no method by which it is possible to render waters organically pure except by filtering; and, in the second place, I know of no practical method of bringing about that result except by the American system of mechanical filtration and purification. As these statements appear strong and unqualified, I think it is important that I should briefly review the history of our knowledge and practice during the course of the past ten years, in relation to this subject.

Some six years ago there was, I think, but one city in the United States which attempted to filter its water, and that was Poughkeepsie on the Hudson. At the present day there are more than one hundred, and the practice is increasing very rapidly. In England, and on the continent of Europe, the practice of filtration is well nigh universal. Some five years ago Jersey City and Newark, in New Jersey, requested me to visit the various water supplies, in England more especially, to study this matter of filtration of their waters, and I found that all the great cities, with the exception of Glasgow, filtered their water supplies. The most conspicuous example is London, with its population of five and a half million of people. Its water supply is almost entirely taken from the River Thames, and that river receives the drainage of a very great population. The towns are compelled, by act of Parliament, to purify their sewage to a certain point, but a great deal of filth finds its way into the Thames. By act of Parliament the several water companies that supply London are compelled to filter their water; and to effect that object they have filter basins which cover more than a hundred acres in area. Their method of filtration is to run the water into large reservoirs containing sand. The sand that does the filtering is about two feet in depth, and supported on a substratum of coarse stone. As the filth is removed it accumulates in a thin layer upon the top of the sand; and when the water—which filters only under the pressure of the four feet, or thereabout, of water standing in the reservoir—filters too slowly, they are compelled to send a force of men into the filter basin, shovel off the top layer of sand and dirt, remove it, wash it, and restore it to the filter bed. The same plan is followed at Berlin and other great cities on the Continent.

HOW THE FILTER BEDS DO THEIR WORK.

It is easy to see how they remove the dirt, the gravel and the suspended matter; but how do these shallow basins of sand remove the living organisms—those organisms with which you are all so familiar under the name of bacteria; those organisms which, when they produce typhoid and other fevers, are known as disease germs? That operation was a complete mystery until the last four or five years. But few people had ever seen or examined bacteria before that period. It is entirely a new topic in this country, and the method by which they were removed from the waters was a profound mystery.

It now has been shown that the bacteria remove the bacteria. The bacteria in the waters are comparatively few of a dangerous character; the great bulk of them are our greatest friends. It is through their aid, together with the oxygen of the air, that the filth in the water is destroyed. They feed upon it and they feed upon each other. Since that knowledge has been obtained, the object now is to cultivate the bacteria. In order to make the filter bed do its work effectively, it is necessary that the growth of the bacteria shall be facilitated until a filter bed becomes populated with an incredible number of millions of them. As the result of their activity they multiply themselves in vast numbers; and they form at the top of the filter beds and between particles of sand, a sort of jelly or slime—a bacteria jelly; and it is by the aid

* Abstract from the address delivered by Professor Leeds before the Chamber of Commerce of Rochester, N. Y., May 12, 1891.

of this bacteria jelly that the bacteria in the unfiltered water are removed. The bacteria come down into the pores of the filter, when they are caught by this jelly and they are consumed. And if the rate of movement of the water is slow enough it is possible to begin with water like that of the River Spree, which is a portion of the water supply of Berlin, containing 100,000 of bacteria to the cubic centimeter, and after passing through one of the filter beds the water which comes out will contain but forty or fifty bacteria. This takes place when the rate of filtration is such that 1,000,000 gallons of water pass through those filter beds per acre in twenty-four hours. If the rate is diminished until only 300,000 gallons pass through in that interval, the bacteria can be diminished until there are only five or ten per cubic centimeter. But this rate is too slow to permit of economical use of the filter beds, and the consequence is that the authorities of Berlin require that the water shall pass through the filter beds at the rate of a million gallons per acre in twenty-four hours. The interesting fact is thus brought out that some of the foulest water, most polluted with sewage, is so filtered at the present day in the capital of Germany; the filtered water is submitted to the most searching criticism of Prof. Koch, whose institute of hygiene is there, and to whose labor our knowledge on this subject is mostly due, and that this foulest of water is there taken, filtered, and then becomes the water supply of Berlin. If we can do as well or better than that, we have every reason to be satisfied that we are on the side of safety.

The foreign filter beds, excellent as they are, have never been introduced practically in the United States. Moreover, there is no prospect that they will be. The amount of water filtered per acre is so small that the first cost is a large one. In the second place, the climate of Europe and England is altogether different from the climate of America. Those filter beds freeze up, even at London, and the engineers are sometimes greatly troubled. In the next place, in England, even in that temperate climate, a great quantity of algæ develop in the filter beds. In the United States, with our severe winters and the great trouble you have experienced in Hemlock Lake, from the growth of algæ, engineers are unwilling to undertake such method of filtration. This being the case, the attention of engineers has been directed to find some way of effecting a result which will satisfy our own needs. And the system that I shall bring to your notice in reference to your immediate wants is this American system.

The filter is simply a case made of boiler iron, of five feet, ten feet, or twenty feet in diameter, made strong enough to stand any pressure to which it is subjected. It contains a bed of sand three and one-half or four feet in depth. The water is passed through the filter under pressure and passes out of the bottom by a series of valves so constructed that they permit the water to pass, but entirely detain the sand. After a time, when the filth accumulates on the surface and through the bed of the sand, the operation is reversed, a current of filtered water under pressure is sent up from below, the sand is washed, and the impurities pass out from a waste pipe, and then filtration is resumed. In practice, after filtering for ten hours, a filter operating on such water as the Genesee River can be purified by washing in ten minutes' time.

That it is possible by such a method to renovate the sand and dirt you will probably have no difficulty in admitting; but what will such a filter do with reference to the bacteria? If it is necessary to pass water at so slow a rate where the pressure is as light as that given by a head of four feet, as is the case in the foreign filter bed, how is it possible to pass the vastly greater quantity through one of these American filters? One of these filters of which I have been speaking, ten feet in diameter, under a pressure of fifteen pounds to the square inch, will filter successfully a quarter of a million of gallons per diem. In order to effect that result it is necessary to have something which will take the place of bacteria jelly that I have described. And the most successful substitute is a jelly made of hydrate alumina. It is obtained in this way: All natural water contains in solution carbonate of lime, to which its hardness is due. When sulphate of alumina is introduced into the water, it is decomposed by the carbonate of lime, and sulphate of alum is formed and hydrate of alumina is set free. It is a perfectly white, translucent jelly. It forms on the surface of the filter bed in contact with the grains of sand, and when the smallest particle of silt or the bacteria come in contact with it they are caught by it and held. It is possible to entirely remove the bacteria from water by use of this jelly. These filters worked in that manner have been repeatedly tested, and that point has been most carefully established.

The water that I have sent around the audience this evening is filtered water. It contains no bacteria. They were removed at the same time that the turbidity and the color were taken out. The question then is, whether the bacteria are to be removed by a bacteria jelly or by means of an alumina jelly. There are some who think that no chemical substitute whatsoever can rightly be employed in the purification of water. It appears to me to adopt such a sentiment is to renounce the advantages which the very elaborate study of this question has given to us. They say that hydrate of alumina, which is one-fourth of alum, is very pernicious to health. If alum ever went into your water supply I would concede the point that it is not a proper thing to use; but it does not go into the filtered water. The alum is so perfectly decomposed that I never have been able to find it in the filtered water. The hydrate of alumina is left behind, and the alumina which goes into your water in a minute amount is also present in natural water itself. If you examine the analysis of the river water you will find that the water contains naturally some alumina. It is the alumina in the soil which makes spring water so bright. It is the alumina in the soil which makes the water of driven wells filtered water. All that is proposed in this method is to take advantage of nature's methods.

In the sample that is before you a quarter of a grain of alum has been used. That is so small an amount that it is difficult to weigh it upon a druggist's balance. Of that quarter of a grain of alum, only one-third is alumina; and one-twelfth of a grain of alumina, or the one-seven hundred thousandth part of the weight of a gallon of water, is sufficient to remove all the dirt and all the bacteria by this process of filtration. The quantity is practically infinitesimal.

Unfortunately, the Genesee water, at the time it was sent to me, was in a very favorable condition. I wish it had been at its worst, because the difference is too slight to show what the process is capable of doing. This method is now in use supplying filtered water in much larger quantities than what you desire to have here. The city of Chattanooga, some four years ago, began taking some three million gallons of water from the Tennessee River. It has now gone on increasing its filtering plant, until it takes six million gallons, and it is all treated by the method I have spoken of. I have here a sample of water taken from the Wabash River at Terre Haute. It is not possible that the Genesee River should ever have water of the character that you see here. It is loaded with mud. The water was so bad that I at first thought, when this sample was submitted to me, that it was a hopeless case. I am interested in this question, as a consulting chemist, from the fact that a great many waters are submitted to me by the people that are engaged in doing this work, and I am desirous of seeing this American system introduced generally. I think it will be universal before many years have passed. And here is one of the samples that was submitted. A plant was put in some year and a half ago to filter this Terre Haute water. The impurities were so great that I said that they could not be successfully handled without using as much as four grains of alum to the gallon. They have been filtering, not three, but four and one-half million gallons of water with a three-million-gallon filter plant. And this has been done with two grains of alum to the gallon, and less. The superintendents have been careful not to use more than that, because of the expense. They use less. And this is the largest amount of alum I have ever known to be used practically in the filtration of water.

I will not detain you longer than by saying I have here a working drawing, showing ten of these vertical filters, ten feet in diamater, which are doing this work at Terre Haute. The water is filtered under a pressure of two hundred pounds, and the filtered water is used for fire purposes as well as for general supply.

Here is the working drawing of a plant at a place in Kansas, a smaller plant. It is the same size as that at Bordentown, in New Jersey. Long Branch has for the past three years filtered and treated all its water in that way. It was much more deeply colored with peat than the Genesee River water was that came to me, or it is possible for the Genesee ever to be colored. It came from a cypress swamp. And the filtered water at Long branch is colorless. And when the health inspector of Providence examined that plant he found that the filtered water contained two bacteria per cubic centimeter, while the unfiltered water contained three hundred.

In conclusion, then, I will say that this method is in use in one hundred of our American towns; that those who are using it are extending their plants to supply the increased demand; that by its use in the filtered samples which I have shown you, the organic nitrogen in the Genesee water was cut down to one-half the amount usually present, and also the water in the Hemlock Lake was cut down by the same amount. The Hemlock water, if filtered by this method, would be 100 per cent. purer than delivered to you as it is, and you consider it, as it is, very excellent water.

At the recent convention of the engineers in Philadelphia the expression of opinion was general that this method of treatment of waters was, in the near future, to be generally adopted. When the city of Liverpool put in its new water supply from Vrnywy Lake, the purest water they could obtain in Wales, they put on the descending main a filter plant; and I said to the chief engineer at Liverpool: "Why do you filter this beautiful mountain water?" and he said to me, "The public opinion in England is so strong in this matter that we cannot supply water unless it is filtered." If you have examined one of those filter systems you will find that all of the filtered water is passed through a well, at the bottom of which there is a pavement of white porcelain, and the engineer and the people are not satisfied without, on looking through a depth of five feet of water, the filtered water should always go over that porcelain and be absolutely colorless. I think the time has gone by in this country when people will be satisfied with taking any water supply without they are made certain of its purity. As I said before, I know of no method of guaranteeing the purity of water except by filtration.

Mr. President, I trust I have been not too lengthy. I wish to answer the question which was asked: "If a temporary supply of 3,000,000 gallons of water is taken from the Genesee River can it be made colorless, can it be made pure from a sanitary standpoint?" I have answered that it can be, and that the method is one in large use, and is a method requiring so moderate an outlay that it has become feasible for the water supply of cities demanding a great amount of water. —*The Stevens Indicator.*

REMOVAL OF SUPERFLUOUS HAIR BY ELECTRICITY.*

By PLYM S. HAYES, M.D., Chicago, Ill.

THE removal of superfluous hairs by means of electrolysis was primarily devised as a purely therapeutic measure. It was only after this method had been demonstrated to be a perfect success in the destruction of hairs in entropium that this procedure was diverted from its strictly therapeutic channel and applied to a broader field, and used in what may be called a cosmetic rather than a therapeutic sense. Even if confined to the cosmetic use, there is a decided therapeutic effect produced in the liberation of many ladies from a self-imposed seclusion, if not actual close confinement, akin to prison life. The gloom produced from this seclusion has frequently made life a burden, and been a factor of no small moment in the development of a melancholia.

A correspondent writes that he understands that this operation is largely a mechanical one, and he desires instruction enough to know how, and then he will be able to do as well as any one. This latter statement he does not make, but, from the tenor of his letter, is readily inferred. The operation is mechanical, much in the same sense that the repairing of a watch is mechanical; but it is not every watchmaker, to say nothing of the broad class of mechanics, to whom we would intrust our valuable watches.

Those who first demonstrated the possibility of the permanent removal of superfluous hair by means of electrolysis did their work so thoroughly and understood the laws of electrolysis so well that but little has been added to the technique of the operation during the past six years.

Whether the operation is for therapeutic or cosmetic purposes two points are to be kept constantly in the mind, namely, to destroy the hair and then see to it that you do not leave indelible proof in scars that you have not done your work thoroughly.

The statement is frequently made that this operation leaves no scars. The frequent occurrence of scars in positions that tell of the destruction of offending hairs, as well as the form of the scar left, gives the lie to the statement. If this were not sufficient, then the applications that we have for the removal or modification of scars, or the completion of the work that some one else has commenced, but by reason of clumsiness has made the patient seek some more skillful operator, will leave no doubt in the minds of all that scars may result.

Without entering into the detail of the operation so well understood, I will take up the points that have aided me most in making the operation a perfect success, and leaving little to be desired, unless it be that the time consumed in its performance may be abridged.

THE NEEDLE.

The history of the changes and modifications in the needle has shown that we did not have all that was to be desired in this important part of our apparatus.

Theoretically, the needle should be so constructed that it will reach the bottom of the hair follicle, and come in contact with the papilla without doing violence to the tissues, and finally, to be so arranged that the current will exert its electrolytic effects only at the point of contact with the papilla. Practically, this is impossible of accomplishment; but in this direction much more has been accomplished than would at first sight seem possible.

I early discovered that a blunt-pointed needle was much better than a sharp one, and a thin one than a thick one.

After a long series of experiments I came to the conclusion that steel was the only material that would give us a needle of sufficient tenuity and yet have the strength and rigidity to accomplish the desired result.

The best material for the needle is found in the jeweler's broach, an instrument for reaming out the jewels in watches. This is ground to (so as to be of) a diameter varying from $\frac{1}{100}$ to $\frac{1}{200}$ of an inch. From the point to a space of one-sixteenth of an inch back it should be slightly thicker than the shaft; although this bulbous point is of advantage, it is not an absolute necessity. The point of the needle is the main thing, and it should represent as nearly as possible a hemisphere. A conical point should never be used, because of the danger of piercing the walls of the hair follicle.

The temper of the jewelers' broach of necessity renders the steel exceedingly brittle, and it has been found of advantage to draw the temper in order to prevent breakage of the needle. This is best accomplished by taking a glass tube of about one-fourth inch in diameter and closing one end, and introducing the needle into the closed tube. This is then held in the flame of an alcohol lamp or Bunsen burner until the tube begins to become slightly red, when it is put aside to cool with the needle in it. When cold the needle will be found to have had its temper drawn, so that it can be bent at right angles and straightened again without breaking. It is still quite rigid enough for our purpose. Should the attempt be made to heat needles as thin as those described in the naked flame they will take fire and burn, thus completely destroying their usefulness. I present for your consideration, to illustrate these facts, some needles prepared as I have directed and furnished by the McIntosh Battery and Optical Company, of Chicago.

It has been with great difficulty that I have been enabled to have the needles manufactured of the diameter given in this paper. While the shape was easily obtained and the finish of the needle all that could be desired, the size was almost, without exception, from three to five times too great. Before using a needle I invariably examine it with a lens of three-fourths inch focus in order to see that the point is the proper shape. If the shape is not as it should be, another needle is selected. My experience has been that I could ill afford to work with a needle that was not as it should be. I have found that a needle bent at an angle varying from 45 to 90 degrees from two to three-eighths of an inch from its point serves my purpose better than a straight one. All things considered, we accomplish our best results with the thinnest needle.

(Those who have once used a needle prepared in the manner described, and as exemplified by the samples shown, will never use any other form of needle.)

THE CURRENT.

The strength of current required (for this operation) varies from three-fourths of a milliampere to a milliampere and one-half, and, in rare instances, possibly three milliamperes. The strength of the current, however, must of necessity be regulated by the amount of chemical action which takes place around the needle, as well as by the amount of pain produced. In this operation the chemical action produced around the needle (the negative electrode) is a much better index than the milliammeter. In fact, the milliammeter is all but a useless instrument in electrolytic epilation.

As a rule, the less current the longer the time required to destroy the tissue, including the hair papilla. From three to six cells of the diamond carbon battery is usually sufficient.

The question has been frequently asked whether storage cells could be used. The reply is, that if three or four storage cells are connected in series for tension, the current obtained from such a battery can be used. The resistance of the tissues of the thin steel needle of the ordinary electrode and of the cords is so great that our milliammeter will register no greater strength of current than as though we had used the same number of Bunsen cells.

* Read at the meeting of the American Electro-Therapeutical Association.

The commercial current from an Edison plant has been successfully used. The pain produced is ordinarily so great as to make its use undesirable. The Edison current has an ordinary pressure of about 110 volts. To reduce this current so that we can use it for epilation, we find that the difficulty to be overcome is that, with our present means of controlling the current, we reduce the amperage much faster than we do the voltage, and, consequently, get a current of tension which is more painful than current obtained from a battery. The results of a number of observations have led me to formulate the following:

Have as little resistance in the circuit outside of the battery as possible.

A battery with large cells and large elements is preferable to one with small elements. Two cells of a storage or galvano-cautery battery are equal to about three cells of a diamond carbon battery. Where the external resistance is as great as it is in this operation, it will be found that the milliammeter will register about one milliampere for three diamond carbon or two storage or galvano-cautery cells. It is thus readily seen that the current from the storage or cautery battery has been so reduced by the resistance of the body and the circuit, in which it is included, as to be unable to heat the needle at all. We must count the volts rather than the amperes. In the above statements, relative to the requisite number of cells of the various batteries required, it will be found that the volts in two cautery cells will equal the number in three diamond carbon cells.

THE OPERATION.

I desire to emphasize but one or two facts rather than to give any detailed account of the operation.

Always use care in introducing the needle, and see that it follows the hair closely.

Do not carry the current so long as to produce a lesion that will form a scar on healing.

If the needle is arrested before it has entered much beyond the neck of the follicle, by reason of the size and density of the hair and root sheaths, allow the current to pass until any adhesions that may exist at the point are overcome. It would be well, in this case, to cause the needle to act on the tissues on all sides of the hair. Remove the hair, and the root sheaths will come with it, if the operation has been carefully done. The reintroduction of the needle in the now empty follicle is easily accomplished, and, if care is used, the papilla will be reached without trouble, and destroyed with more certainty and less destruction of tissue than as though this method had not been followed. This method is only to be used in those cases where the needle does not follow the hair to the papilla when first introduced. The reintroduction of the needle insures the destruction of a much greater percentage of hairs than where this is not done.

IN CONCLUSION.

We can state that but little that is new has been added to our methods in electrolytic epilation during the past few years. The advance in this branch has been brought about by improving the apparatus at hand, rather than by the introduction of new apparatus.

In the *needle* we note the exceeding thinness of it, the hemispherical and bulbous shape of the point, and the drawing of the temper. In the *battery*, that cells with comparative large amperage (large surface of plates) are of advantage. In the *circuit*, outside of the battery, that the conductors shall offer but little resistance; the connections be good; the positive electrode large; and that every piece of apparatus, such as a rheostat and milliammeter, that would interpose resistance, be left out of the circuit. In the *operation*, that it is advisable in many instances to remove the hair before the needle has reached, and the current has destroyed, the papilla, and then reintroduce the needle, which now readily glides into the follicle made vacant by the hair and its root sheath.

With the most approved apparatus the ultimate success depends as much upon the man as the means. Every operator leaves his record on the face of his subjects, and success or failure, as well as gratitude or regret (according to the result), is accorded to him who essays this simple yet delicate operation.

RAPID DETERMINATION OF CARBON DIOXIDE IN FURNACE GASES.

THE apparatus, as shown in the figure, consists of a vessel *a* having a capacity of 100 c. c. and provided with an inlet and outlet tube. A graduated tube *c*,

APPARATUS FOR DETERMINING CARBONIC DIOXIDE.

divided into c. c., and fitted with a stopcock, is ground into *a* at *b*. The stopper *b* is bored at the side, so that communication between the vessel *a* and its side tubes can be made or closed.

The vessel *a* is filled with the furnace gas to be tested by drawing it through the tube *e* by means of the rubber ball *g* in the usual way. The graduated tube *c* is filled with caustic soda solution of specific gravity 1·25 to the mark *f*. A blank experiment is first made by filling the vessel *a* with air free from carbon dioxide, closing the openings of the side tubes by turning the stopper *b* and opening the cock communicating with *c*. The liquid in *c* falls to a certain point, which is made the zero of the instrument. Correction for temperature and pressure is neglected, as the instrument is only intended for rough technical purposes.

In making a determination, the vessel *a* having been filled with the gas to be tested, the soda solution is allowed to flow in until absorption of carbon dioxide is complete and no more can enter. The volume of soda solution used then gives at once the percentage of carbon dioxide in the sample.

Determinations made by this instrument agree well with those made by more accurate apparatus.—*Jour. S. Chem. Ind.*

GENERATION OF CHLORINE.

By G. GRUNEWALD.

THE flask A contains the manganese dioxide and is provided with a rubber stopper having two holes, through one of which the bent tube *a*, *b*, *c*, *d* passes

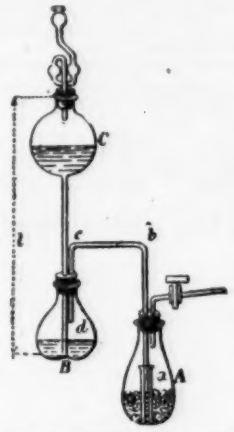


FIG. 1.—APPARATUS FOR GENERATION OF CHLORINE.

to the flask B, while a tube provided with a stopcock is inserted in the other. By opening or closing this stopcock the acid is drawn into or forced back from the flask A, the acid being contained in B and C. The bent tube *a*, *b*, *c*, *d*, must be capable of being moved up and down. To prevent the stopping up of the bent tube, it is provided with a number of small holes at the bottom, and is surrounded by a wider tube, also containing small holes at the sides, as shown

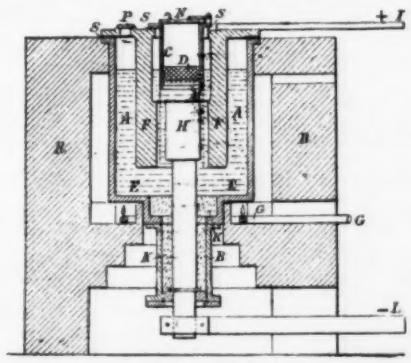
FIG. 2.

in Fig. 2. The dimensions recommended are as follows: Flask A, 300 c. c.; flask B, 320 c. c.; bulb C, 600 c. c.; *a*, *b*, 24 cm.; *b*, *c*, 12 cm.; *c*, *d*, 12 cm.; *l*, 40 cm. For larger forms of apparatus these proportions should be adhered to. The apparatus can also be employed for the continuous generation of other gases that require heat for their production.—*Ibid.*

IMPROVEMENT IN THE MANUFACTURE OF SODIUM AND POTASSIUM.

By H. Y. CASTNER, London.

FUSED caustic soda or potash at as low a temperature as possible is decomposed by an electric current. When the temperature is high, the power of the bath to absorb both the metal and oxygen becomes very



APPARATUS FOR THE PRODUCTION OF SODIUM AND POTASSIUM.

great, and practically no decomposition takes place. The material therefore should not be heated to a temperature higher than 20° above its melting point, and at the same time facilities should be given for the rapid separation of the librated metal from the bath. The apparatus consists of an iron vessel A, mounted in brickwork R, in which the caustic soda is melted by heat supplied by means of the gas burner G. The vessel is provided by one or more base pipes or extensions B, adapted to receive the negative electrode H, which is made of metal, the space K being filled with molten caustic, which becomes set and seals H in position. Above this electrode is suspended a tubular iron receptacle C, provided with a lid N, and with a cylindrical piece of iron wire gauze M attached to its lower end. This gauze surrounds H and rests between it and F, the positive electrode. P is an opening for the escape of gas and for the insertion of a thermometer, and S is an asbestos or other insulating medium. The current is supplied through I and L.

The size of the electrodes and their distance apart should be in proportion to the quantity of current. If they be larger than necessary, the elements will be subjected to a greater chance of being absorbed by the bath and recombining with a consequent waste of electrical energy. On the other hand, if they are too small, the resistance will increase and the bath become overheated just at that part where an elevated temperature is most objectionable. When the decomposition takes place, the liberated metal rises and floats on the surface of the caustic in C, whence it is removed by a finely perforated spoon which allows the caustic to drain through while retaining the metal. Fresh caustic is added to the bath from time to time, so that the process may be worked continuously.

ON THE NATURE OF SOLUTION.

By J. ALFRED WANKLYN, W. JOHNSTONE, and W. J. COOPER.*

THE venerable Dalton made the great discovery, about the year 1840, that contraction occurs when salts dissolve in water. In some instances the contraction is so great that the volume of the solution of the salt is not greater than that of the water itself—the contraction being as large as the volume of the anhydrous salt existing in the solution. Dalton experimented upon the same salt in its hydrated and in its anhydrous condition, and he also extended his investigation to a great variety of salts, and his results he sums up as follows:† "I have tried the carbonates, the sulphates, the nitrates, the muriates or chlorides, the phosphates, the arseniates, the oxalates, the citrates, the tartrates, the acetates, etc., and have been uniformly successful; only *the water adds to the bulk*, and *the solid matter adds to the weight*."

Such was the condition in which Dalton left this subject about the year 1840.

Taking up the investigation where Dalton left off, we find that in the majority of cases there is indeed considerable contraction when salts dissolve in water, but that the degree of contraction varies very widely with different salts. In some instances in which mineral matter dissolves in water, the contraction is so great that the volume of the solution is actually less than the volume of the water which forms it. This is strikingly exemplified by lime water, which occupies less space than the water which it contains. On the other hand, there are cases where the volume of the solution of a mineral salt is almost as great as the sum of the volume of the salt plus the volume of the water in the solution. (The solution of nitrate of silver is a case in point.) There are even instances where expansion takes place. This is exemplified by some ammoniacal salts, where the volume of the solution has been found to exceed the sum of the volumes of water and dry salt.

Finally, there is the very important and, we think, very common case where solution takes place without any change of volume whatever. Such a case is afforded by solutions of cane sugar,‡ which dissolves in water in almost all proportions, and the solutions of which occupy exactly the same volume as the separate water and sugar which enter into them.

A characteristic example of solution is afforded by sugar and water; and we hold that solution is mutual permeation without change of volume, as exemplified by sugar and water.

The changes of volume so frequently observed, in the instance of mineral salts, are due to chemical action, which is often a concomitant of solution.

In order to trace the connection between the specific gravity of solutions and the composition of solutions, the following method may be followed with advantage.

We regard solutions as being generated by the entrance of successive units of weight into a large unit of volume. The unit of weight is one gramme. The unit of volume is 100 cubic centim., or one liter. The unit of volume is taken to be constantly filled with the solvent except in so far as it is occupied by the thing dissolved.

i = the increment coefficient; that is to say, the increment of weight occasioned by the entrance of one gramme of the substance into 100 cubic centim. or one liter of the solution. It is found experimentally by weighing the 100 cubic centim. or the liter of the solution, and subtracting the weight of 100 cubic centim. or a liter of the pure solvent. If the solution contains more or less than one gramme of the substance in the 100 cubic centim. or liter of solution, the number of grammes must be ascertained and used as a divisor.

When one gramme of a substance is inserted into 100 cubic centim. occupied by a solvent, one of three things must happen:

(1) There may be absolutely no change in volume—neither contraction nor expansion. When one gramme of mercury is dropped into 100 cubic centim. of water, there is neither contraction nor expansion, and the gramme of mercury simply displaces its own volume of water, which overflows out of the 100 cubic centim. measure. Sp. gr. being the specific gravity of mercury, the quantity of water which overflows will be $\frac{1}{\text{sp. gr.}}$; and the increment of weight in that case would be $1 - \frac{1}{\text{sp. gr.}}$

Such a value we represent by i_1.

$$i_1 = 1 - \frac{1}{\text{sp. gr.}}$$

This is the case of sugar, and no doubt of many or-

* Communicated by the authors.

† Henry's "Life of Dalton" (Cavendish Society), p. 193.

‡ *Vide* Chemical News (1891), vol. lxiv., p. 27, Wanklyn and Cooper.

ganic substances which simply dissolve in water without chemical action of any kind.

(2) There may be contraction. This is exemplified by common salt and water. When one gramme of common salt is inserted into 100 cubic centim. of water, the displaced water is partly condensed and retained in the 100 cubic centim.

$i - i_1$ = the condensate;

that is to say, the weight of the water which, instead of overflowing, is retained in the vessel when one gramme of salt dissolves, so as to give 100 cubic centim. of the solution.

(3) There may be expansion. In such a case, when one gramme enters the 100 cubic centim. or the liter, a larger quantity than $\frac{1}{\text{sp. gr.}}$ will overflow, and $i - i_1$ becomes a minus quantity.

This is exemplified by chloride of ammonium, which undergoes decomposition when it is dissolved in water, and the volume of the solution of that salt actually exceeds the sum of the volumes of the water and the salt in their separate condition.

In a series of papers which have recently appeared in the *Chemical News*, we have treated solution from this point of view, and shown that the condensate ($i - i_1$), in the case of very many salts, bears an atomic relation to the gramme of salt which occasions it.

SUGAR AND WATER.

The ordinary tables of the specific gravities of solutions of different strengths are constructed so as to mask the regularity of the relation between specific gravity and strength. The common sugar table, for instance, gives the specific gravities corresponding to the strength represented in percentage by weight. That mode of statement hides the regularity; but when the table is transformed so as to set out strength in terms of the number of grammes of sugar in 100 cubic centim. of solution, then there are indications of regularity. By a very obvious method of calculation this transformation may be effected. The ordinary tables when so treated exhibit some departure from regularity.

We have undertaken a revision of the table, and our result is that these departures from regularity are experimental errors.

Our results are as follows:

	Number of grms. of Cane-Sugar in litre of solution.	Specific Gravity.	i
° Fahr.			
65·5	1·341	1000·52	·3878
54	1·341	1000·52	·3878
53·7	1·341	1000·52	·3878
53·7	9·878	1003·84	·3887
56·0	104·580	1040·60	·3882
59·0	749·30	1282·00	·3762

In these experiments we have compared the weight of the sugar solutions with the weight of an equal volume of distilled water at the same temperature as the sugar solution, and in each instance have used a half liter specific gravity bottle,* except in the last experiment.

The last measurement was made with a 100 cubic centim. bottle and has not the same claim to be considered highly accurate as the other five measurements; and we attribute the slight difference in that case to experimental error, and to another cause which may be considered hereafter.

The value of i for sugar we find therefore to be 0·388, and it is constant over a very wide range, viz., from one gramme of sugar per liter of solution up to 750 grammes of sugar per liter of solution.

The specific gravity of solid sugar required in order to make $i_1 = 0·388$ is 1·634. The specific gravity of sugar is given in the text books as 1·606,† which would make $i_1 = 0·3773$.

Sugar, therefore, presents an example of equality between i and i_1, that is to say, its solutions in water occupy exactly the same volume as the separate water and sugar which form them.

At the beginning of this paper we called attention to Dalton's discovery of the contraction which takes place when salts dissolve in water. Dalton also experimented upon sugar, but failed to notice that in that case there is no contraction; and it has been reserved for ourselves, after the lapse of half a century, to record that there are cases, such as that of sugar, where there is rigid maintenance of volume.

Laboratory, New Malden, Surrey.

—*Phil. Mag.*

LEAD IN CANNED GOODS.

By J. PINETTE.

THE exact limit for lead in the covering of tin plate used for vessels containing preserved food, and in their soldered seams, being prescribed by law in Germany, its determination is of some moment. Although no such regulation exists in this country, the intrinsic importance of the question is as great. The plan suggested consists in avoiding the troublesome process of scraping off the tin from the sheet iron, and in simply acting upon fragments of the vessel with dilute nitric acid until the iron is laid bare and determining the tin and lead in the solution, the later being dissolved as nitrate, the former chiefly remaining as metastannic acid. As it is only of importance to ascertain the ratio of tin to lead this plan suffices; it assumes, however, that the tin plate is coated with the same alloy on both sides. The fact that some iron is also dissolved is of no moment. The examination of the solder presents no difficulty, but it must be remembered that its composition may vary at different parts of the same vessel, that used for finally closing the "tin" after sterilization being usually richest in lead on account of its greater fusibility and consequent ease in working. A can of American fruit was tinned with an alloy containing 0·55 per cent. of lead; its solder under the lid contained 50·84 per cent. Another of corned beef gave imponderable traces of lead in the tinning, and 50·06 per cent. of lead under the cover.—*Chem. Zeit., Analyst.*

* *Vide* Wanklyn's "Water Analysis" (Kegan Paul, Trench, and Trubner), eighth edition, p. 78.

† *Vide* Watt's "Dictionary of Chemistry," vol. v., p. 470.

DETECTION OF THE CONTAMINATION OF WATER WITH SEWAGE.

By PETER GRIESS.

THE author dilutes paradiazobenzol sulphuric acid with 100 parts of water, and adds a little soda lye in excess. The solution must always be used when fresh, as it soon becomes colored spontaneously. The water to be examined is placed in a tall cylinder of colorless glass holding about 100 c. c., which is placed before a window upon a white surface. To the water are then added two to four drops of the diazo solution. The whole is well stirred up and it is carefully observed. If no change of color takes place within five minutes, we may infer the almost entire absence of organic excretions or products of decomposition. A yellow color more or less decided shows the presence of a more or less considerable quantity of such matter. By means of this reaction the author has detected normal human urine when diluted with 5,000 parts of water, and the urine of horses when diluted with 50,000 parts.—*Ber. Deutsch. Chem. Gesell.*

THE SCIENTIFIC AMERICAN
Architects and Builders Edition.
$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

THE SCIENTIFIC AMERICAN
Cyclopedia of Receipts,
NOTES AND QUERIES.

650 PAGES. PRICE $5.

This splendid work contains a careful compilation of the most useful Receipts and Replies given in the Notes and Queries of correspondents as published in the SCIENTIFIC AMERICAN during nearly half a century past; together with many valuable and important additions.

Over Twelve Thousand selected receipts are here collected; Nearly every branch of the useful arts being represented. It is by far the most comprehensive volume of the kind ever placed before the public.

The work may be regarded as the product of the studies and practical experience of the ablest chemists and workers in all parts of the world; the information given being of the highest value, arranged and condensed in concise form, convenient for ready use.

Almost every inquiry that can be thought of, relating to formulæ used in the various manufacturing industries, will here be found answered.

Instructions for working many different processes in the arts are given. How to make and prepare many different articles and goods are set forth.

Those who are engaged in any branch of industry probably will find in this book much that is of practical value in their respective callings.

Those who are in search of independent business or employment, relating to the manufacture and sale of useful articles, will find in it hundreds of most excellent suggestions.

MUNN & CO., Publishers,
361 Broadway, New York.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—The Mount Blanc Observatory.—A very remarkable work in process of execution at Mount Blanc.—An observatory for the study of physical astronomy.—The determination of basis for a foundation under the snow.—4 illustrations..... 13324

II. CHEMISTRY.—Detection of the Contamination of Water with Sewage.—By PETER GRIES.—A very simple and rapid process for detecting traces of organic matter in water..... 13330
Generation of Chlorine.—By G. GRUNEWALD.—An apparatus for generating chlorine and other gases requiring heat for their evolution.—2 illustrations..... 13329
Improvement in the Manufacture of Sodium and Potassium.—By H. Y. CASTNER.—A description of the Castner electrolytic process for manufacturing the metals of the alkali.—1 illustration 13329
Lead in Canned Goods.—By J. PINETTE.—Importance of this question and suggestions for carrying out the analysis of canning metal for the determination of the proportion of lead in its coating..... 13330
On the Nature of Solution.—By J. ALFRED WANKLYN, W. JOHNSTONE, and W. J. COOPER.—Dalton's early investigation of solution and present aspect of the theory of solution as evolved from the most recent studies..... 13329
Rapid Determination of Carbon Dioxide in Furnace Gases.—A very simple apparatus and rapid process for effecting this important determination.—Applicable to the work of the gas engineer and metallurgist.—1 illustration..... 13329
The Purification of Water.—By ALBERT R. LEEDS.—An abstract of a recent address by Prof. Leeds before the Rochester Chamber of Commerce, touching on the introduction of purification processes for water supply of the cities of Europe and America, and the different conditions obtaining in the cities in question..... 13327

III. DECORATIVE ART.—The Decorative Treatment of Natural Foliage.—By HUGH STANNUS.—General hints and suggestions in continuation of this subject, treating of borders, friezes, accessory objects, animals, and on the importance of keeping the rules out of sight.—6 illustrations..... 13322

IV. ELECTRICITY.—Electric Cigar Lighter.—An automatic cigar lighter in the shape of an ordinary cigar.—2 illustrations..... 13321
Recent Progress in the Science of Magnetism.—By B. S. GILES.—A prize paper on magnetism, treating of the most recent developments and modifications in its theory.—1 illustration..... 13319
Penny-in-the-Slot Electric Light..... 13321

V. GEOGRAPHY.—The Victoria Cataracts.—A wonderful cataract in Brazil.—How it was reached.—With adventures of the explorer and a description of the wonderful scene.—1 illustration..... 13325

VI. HYGIENE.—Removal of Superfluous Hair by Electricity.—By PLYM S. HAYES, M.D.—The removal or superfluous hair by electrolysis.—Its last developments and details as to the strength of current and other practical points in the work..... 13328

VII. MECHANICAL ENGINEERING.—Rivet Inserting Machine.—A machine for inserting and clamping bifurcated rivets, such as are used in the manufacture of belting, overshoes, horse clothing, and many similar purposes, with suggestions for further application.—1 illustration..... 13321

VIII. MISCELLANEOUS.—The Strongest Man on Earth.—A recent feat achieved in London by the athlete Sampson; lifting a weight of 3,80) pounds, consisting of two horses and two men; its effect on the performer.—1 illustration..... 13327
To Cut a Five-Pointed Star from Paper with a Single Clip of the Scissors.—A very pretty example of paper cutting available for decoration of Christmas trees.—1 illustration..... 13327

IX. NAVAL ENGINEERING.—H. M. S. Nelson.—A recently detailed flagship of the British Navy; her armament and general dimensions.—1 illustration..... 13319

X. PALÆONTOLOGY.—Fossil Birds in the British Museum.—Interesting series of fossil skeletons and remains in the British Museum, from different parts of the world, representing a phase of very early bird life.—4 illustrations..... 13326

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.

The Scientific American Supplement. Index for Vol. 32.

JULY—DECEMBER, 1891.

The * Indicates that the Article is Illustrated with Engravings.

A

Acetanilide....12961
Acetylphenylhydrazin....12931
Acid, camphoric....12931
Acid, citric, in milk....13118
Acid, citric, in wine....13118
Acid, lactic....12965
Acid naphthoric....12931
Acid, phosphoric, glacial....13174
Acid, phosphoric, pure....13130
Acid, sulphuric, electrolysis....13014
Acid, uric, in nervous troubles....13010
Acids, fatty, sap, resin....13154
Advertising, street....*12979
Æolus, British cruiser....13206
Agaricine....12931
Albuminoid, new, from oats....13286
Alcohol, production....13125
Alkali, caustic process....13154
Alkaloid for coca leaves....13046
Almond culture....13187
Aluminum manufacture....13024
Aluminum process, electrolyte....12997
Aluminum, production of....12999
Ammonia....13004
Ammonia, soda process....13029
Ammonia, synthesis of....13151
Amylene hydrate....12931
Analysis, volumetric....*13217
Animals, prehistoric....13028
Animals, wonderful, remains....13230
Anthrarobin....12931
Antipyrin....12931
Antiseptic, new....12961
Ants....13140
Apadana of Artaxerxes....*13060
Apples....13059
Archer, fish....*13027
Arches, masonry....*13192
Arcturus, recent conceptions of....13060
Aristol....12931
Armorclad ship Brennus....*13272
Armor plate on battleships....*13127
Army, French, maneuvers....*13176
Art in modern carriages....13277
Art, schoolmaster on....13044
Asbestos, composition....12966
Asphaltum....13099
Association, Brit., chemistry at....13198
Association, Science, American....13201
Aster, New Zealand....*13058
Astronomer, modern, work of....13314
Atlantic Coast, subsidence....13043
Atmosphere, the upper....*13316
Atoms, intelligent....13256

B

Bacteria, relat. to surgery....12944
Baldness, lotions for....13156
Balloon accident....13026
Ballooning, military....*13177
Barges, river and canal....*13246
Barmenit, Rueger's....13213
Bath, shower, portable....*12963
Battery, De Lalande's....*13006
Battle ship Nelson....*13319
Beaming machine....*13100
Becquerel, Edmund....*12924
Beeswax, analysis of....*13318
Bell, great, of Montmartre....*13287
Bellflower, pyramidal....*12933
Bengal, tiger-netting in....*12978
Benzene....12934
Benzoyl-anilide....12931
Benzoyl guaiacol....12931
Berlinit....13213
Bessemer, Sir Henry....*13047
Betai....12931
Bicycle race....*12994
Birds, fossil, Brit. Mus....*13326
Birds, song....13221
Bismuth salicylate....12931
Blake, British cruiser....*13294
Blanco Encalada, sinking of....*12951
Bleaching apparatus, new....*13133
Bleaching, cotton....13024
Bleaching of jute....13251
Blower, root, for moving coal....*13146
Blower for soap bubbles....*13283
Blowpipe, improved....*13151
Blue, liquid, for dyeing....13254
Boating on Mississippi....13047
Boats, electric....*13019
Boats, life, steel....*13033
Bogaslov volcano....13281
Boiler explosions, causes of....*13176
Boiler flue flanges, drilling....*13306
Boiler incrustation....*12990
Boilers, riveted joints in....*12928, *12936
Borax, source of....12921
Boston Navy Yard....13272
Botany, economic, Louisiana....12932
Brake, air, questions on....12985
Brennus, warship....*13272
Brick press....*13053
Bridge over the Aurance....*13177
Bridge, Lyons....*13175
Bridge, North River....*13211
Bridge over river Barrow....*13001
Bridge, Riparia....*13303
Bridges, recent....13016
Bridges, rope....*13163
Bromoform....12931
Bronzing....13276
Brushes, hair, to clean....13117
Budapest electric tramway....*12923
Buildings, high, Chicago....13017
Bullion, silver, refining....*13091
Burial customs, Vaudoux....13219

C

Cadiz, discoveries at....*13298
Cadmium electric evap....*12958
Cadmium yellow....12975
California raisin industry....13243
Camphor, Florida....13068
Camphor, Formosa....12956
Canal, Kioto-Fu....*12999
Canal, ship, German, new....*12999
Canal, ship, North sea....13224
Canned goods, lead in....13330
Canon, Big Horn, trip through....13235
Cant hook handles....13063
Car painters' convention....13225
Car traction by battery....12950
Car wheels, steel, casting....*13146
Cars, cleaning....13225
Carbon bisulph., ignition....13053
Carbon, dioxide, deter....*13329
Carbon oxide, nickel....13147
Carpet weaving, Persian....13051
Carpets, stair, wire....*13106
Carriages, modern, art in....13277
Cascade tunnel....*13207
Cataracts, Victoria, Brazil....*13325
Chains, steel, weldless....*13086
Cecille, war ship....*13062
Celluloid....13062
Celmisia spectabilis....13058
Cement for iron castings....12968
Cement, Portland....13308
Cetrarin....12931
Chelmon, fish....*13027
Chemistry at British Assoc....13198
Chemistry, photographic....13188, 13198, 13215
Chicago, high buildings of....13017
Chicago, street tunnel....*13095
Chicago World's Fair....*13055
Chile, civil war in....*12951
Chile, recent battles in....*13240
Chimney, Narrag. Elec. Light Co.*13191
Chimpanzee, the....*13183
Chloralamide....12931
Chloralurethan....12931
Chlorine, generation of....*13329
Chromate manuf., new proc....13254
Chrome yellow, manuf....13166
Chromium fluoride, uses of....13166
Cigar lighter, electric....*13321
Circuits, underground....13116
Cities, ancient, of Pharaohs....12982
Climate, changes, south. hemis....13093
Clock, astronomical....*12980
Cloud compellers and the press....13161
Clouds, solid and liquid part....13076
Coal....13158
Coal, moving by blowing....*13146
Coal product of West....12981
Coast, Atlantic, subsidence....13043
Coca leaves, new alkaloid of....13046
Cocas pynaerti....*13048
Cold and mortality....13244
College, Sibley, lectures....*12952, 13044, 13267
Colorado Desert Lake....13241
Colors, action of milling....13065
Compass, mariners'....13063
Concon, battle of....*13240
Concrete, Portland....13308
Contraction on solution....13029
Copper in lemon oil....13046
Copper ores, electrolyt. pro....12994
Copper resources of U. S....12987
Cotton bleaching....13024
Cotton seed, products of....13261
Countersinking machine....*13034
Coupler, M. C. B., gauges for....*13306
Cracks in metal, to find....12969
Crane, locomotive....*12967
Cranks set on angle....*13164
Creosote....13061
Creolin....12931
Cresalol....12931
Cruiser, British, Æolus....13293
Cruiser, British, Blake....*13294
Cruiser, Presidente Pinto....*13307
Cruisers, British, new....12987
Cryogen, Cailletet's....*13125
Crystallization....*12970
Current curves, photo. record....*13219
Current systems, alternating....*13130
Currents, alternating, action....13308
Currents, alternating, high....12960
Currents, high tension....*12944
Curve ranger, Trotter....*13291
Custom House, Chinese....13173
Cyclostat....*13250
Cylinders, gas, how made....*13083

D

Dam, Davis Island....*12983
Danube, iron gates of....*13038
Davis Island dam....*12983
Decorative treatment of foliage....*13322
Detection of sewage....13330
Developer, new....13053
Developing without dark room....*12955
Dials, sun....*12946
Diamond cutting industry, U. S....12942
Diamond mines, African....*13042
Diffusion battery, Kousmine....13182
Diffusion process for sugar....*13178
Discoveries at Cadiz....*13298
Diseases of pomaceous fruits....13205
Dolphin fishing....*13282
Dove cotes, military....*13162, *13088
Draught of road vehicles....*13274
Drawing, perspective....12961
Dredger, Lobnitz....*13128
Dresses, silk, and work....13313
Drilling machine, flange....*13306
Drowning, a case of....13091
Drowning, resuscitation from....*12962
Drying machine for warp....*13100
Drying, theory of....13194
Duck hunting in Scotland....*13297
Duster, compressed air....13047
Dyeing, uniformity in....12968
Dyes, fast and fugitive....12940, 12955
Dynamo and engine....*13143
Dynamo, horse power of....13101
Dynamo, Kennedy's....*13280

E

Earth, orbital motion....*13260
Earthquake, Central America....*13202
East, explorations in....13074
Elderly, exercise for the....13201
Electric boats....*13019
Electric cigar lighter....*13221
Electric discharge in tubes....*12943, 12962
Electric evaporation....*12958
Electric furnace, Edison....*13193
Electric heating....*13180
Electric horse power....13101
Electric lamp for projection....*12970
Electric light, penny-in-the slot....13221
Electric machine, Wimshurst....*13222
Electric power, storage system....13251
Electric projector, Edison....*13307
Electric railway, London....13126
Electric railways, develop....13143
Electric railways, growth....13017
Electric tramway, Budapest....*12929
Electricity, fire hazards from....13267
Electricity, meter, Teague....*12960
Electricity, measurement....13129
Electricity in purifying water....12975
Elect., removal of hair by....13328
Electrolysis, appl. to analysis....12949
Electrostatic safety device....*12944
Electromagnet in eye surgery....*12996
Electrometers, pocket....*13305
Electro-plating, hardness of....*13308
Empress of India, H. M. S....12967
Emulsion, collodion....13228
Emulsion, new....13040
Energy, transf. of heat....13273
Engine, compressed air....*13304
Engine, ether....*13223
Engine, fire, steam....*13068
Engineering, architectural....*13034
Engineering, harbor....13019
Engineering, marine, review of....13095, 13118
Engineering, progress in....13129
Engineering works of 1890....13002, 13016
Eremuri, Himalayan....*13242
Ether engine, Susini's....*13223
Ethylenimine hydrochloride....12931
Evaporation, electric....*12958
Exalgine....12931
Exchange, Labor, Paris....*13113
Exercise for elderly people....13201
Exhibition, electrical, Frankfort....*13182
Extinguisher, fire, new....*13114
Eye, photographic view....*13010
Eyesight, care of in youth....13135
Eye surgery, electromagnet in....*12996

F

Fair, World's, Chicago....*13055
Falls, Grand, of Labrador....13140
Falls, Wollomombi....*13281
Faraday centenary....*12993
Fat in milk, estimation....*13301
Fauna of Thibet....*13203
Feed apparatus distilling....*13038
Ferment, butyric....*13102
Ferrotype process....13022
Fertilizers, analysis of....13263
Films, silicon....13029
Filter press, new....*13038
Filtration, sand....13026
Fire engine, steam....*13088
Fire escape, rope....*13225
Fire hazards from electric....13267
Fires, extinguishing....13114
Fishes, curious....*13027
Flight, mechanical....13050
Florida camphor....13068
Flowers, shell....*12919
Fluorine, action on phosphorus....12982
Fluorine, researches upon....*13299
Flying machine, Maxim....13032
Foliage, natural, decora. treat....*13248, *13264, *13277, *13311, *13322
Food, canned, dangers of....13190
Food, canned, tin in....13253
Forging press....*13224
Formosa camphor....12956
Fossil birds, Brit. Mus....*13326
Frankfort electrical exhibition....*13182
Freezing apparatus, new....*12968
Freezing mixtures....12949
Fruit districts....13205
Fruits, small....13204
Fumes, annihilator....*12955
Furnace, electric, Edison....*13193

G

Galenicals, alkaloidal....12974
Galvanizing, new process of....13110
Gas cylinders, how made....*13083
Gas generator, Simplex....*13309
Gas leakage....13275
Gas, a new....13009
Gas, petroleum....13046
Gas for ventilation....12962
Gases, compression of....*12979
Gates, iron, of Danube....*12938
Gauges for M. C. B. coupler....*13306
Gear, spur, machine, cut....*13099
Gearing, changeable speed....*13129
Germ plasm and the soul....12946
Gemini, launch....*13246
Generator, alternating current....*13280
Generator, gas, Simplex....*13309
Generator, triple current....*13182
Glacial period, cause of....13075
Glass, sheet, from molten metal....13086
Glass, substitute for....*13100
Glaucoma, treatment of....13246
Go-devil, the....*13209
Goods, canned, lead in....13330
Granite vein, gem bearing....13141
Grapevine culture in France....*13186
Great Eastern, last of....*13070
Great Eastern, last days of....*13258
Guaiacol....12931
Gum arabic and substitutes....*13107, 13193
Gun, 110 ton, firing....*12962
Gun barrels, browning....13261
Gun cotton, manufacture....13285
Gun, pneumatic, 6-inch....*13164
Gun wrinkles....13260
Guns, rapid fire, Canet....*13093
Gunnera perpensa....*13075
Gunpowder, smokeless....13114

H

Hair brushes, to clean....13117
Hair, removal by elect....13328
Ham preserver....13213
Harbor engineering....13019
Haulage of road vehicles....*13274
Heat, transf. into energy....13273
Heating, electric....*13180
Helix forming machine....*12969
Helmholtz, Von, Prof....*13152
Hemlock and parsley....13242
Herschel, photographic work....13020
Himalayas....12979
Hood, H. M. S....*13093
Horse power, electrical....13101
Horse, prehistoric, American....*13290
Horseshoe, development of....*13083
Horses, haulage by....*13274
House, the little....13120
Huggins, Dr. William....*13092
Hybridization of plants....13204
Hydracetin....12931
Hydrastinine....12961
Hydrogen, preparation of....*13237
Hydrogen through electrolysis....*13079
Hydroxylamine....12931
Hypnone....12931
Hypnotism, experiments in....13077
Hypothesis, nebular....13092

I

Ichthyol....12931
India, rainmakers in....*13159
Indicator, laboratory....*13114
Induction, magnetic, molec. proc.*13229
Ink, copying....13230
Ink, India....13068
Ink, marking....13220
Insect pests, killing....*12977
Insects, aquatic, life of....13183
Insecticides, micro-organisms as....13206
Iodine trichloride....12961
Iodoform bituminate....12931
Iodol....12931
Ions, velocities of....12994
Ironclad Redoutable....*13127
Iron, influence of heat....13041
Iron, manganese in....12934
Iron ore deposits....13200
Iron, pig, desulphurization....*13252
Island, Bogaslov, volcano of....13281
Itata, ship....*13250

J

Jacket, seamless....*12963
Jardim, Silva....*13009
Jean Bart, warship....*12987
Jelly, reactions in....12972
Jet propulsion....*12999
Jibon, valley of....*13202
Jointa, riveted....*12952
Joints, riveted, in boiler shells....*12928, *12936
Jugglery....13070
Jute, bleaching of....13251

K

Kalitype process....13022
Keir, bucking....*13052
Keyboard, new....*13167
Kioto-Fu canal....*12999
Kite photography....*13215

L

Labor Exchange, Paris....*13113
Laboratory, physical, indicator....*13114
Labrador, coast of....13101
Labrador, Grand Falls of....13140
Lake, Colorado Desert....13241
Lamp for lantern projection....*12970
Lanoline....12961
Launch, twin-screw....*13246
Lavender....*13019
Lead in canned goods....13330
Lead pipes, worms in....13151
Leaves, starch in....*13135

Lectures, Sibley College ..*12952, 13207 13044
Lemon oil, copper in ..13046
Lemons, oil of ..13013
Lens, mirror ..*13219
Levosin ..13045
Leyden jar experiments ..13065
Life boats, steel ..*13053
Light, effect on growth ..13199
Light, electric, penny-in-the slot..13321
Lighter, cigar, electric ..*13321
Lime sucrate, develop. with ..13280
Limes, oil of ..13013
Limestone industry, our ..12981
Liquids, compressibility ..13094
Literature, chemical, indexing ..13301
Locomotive and rail spike ..13292
Locomotive, rack ..*13015
Locomotive, the first ..13262
Locomotives, compressed air ..*13304
Locomotives, painting ..13225
London Eiffel tower ..*12999
London electric railway ..13198
London-Paris telephone ..*13131
London, transit in ..12905
Los Angeles cable railway ..*13146
Louisiana, vegetation of ..13262
Lye tanks ..*13194
Lyons bridge ..*13175

M

Machine, rivet inserting ..*13321
Magnetism, recent prog. in ..*13319
Mail steamer Scot ..*13000
Malt vinegar ..12975
Man, strongest, Sampson ..*13327
Mandioca ..13011
Manganese in iron and steel ..12934
Mankind, study of ..13141
Marceau, turret ship ..*13118
Mat for electric heating ..*13181
Mat, wire, improved ..*13166
Meat preservative, new ..13212
Medicine, progress of ..13103
Mercury, peptoglutine ..12961
Mercury, phenate ..12961
Mercury, salicylate ..12961
Mercury, succinate ..12961
Mercury weighing machine ..*13250
Merry-go-round, new ..*13357
Metal, fluid, rolling ..*13213
Metal, sheets of, new process ..13086
Metals, evaporation of ..*12958
Metals, magnetization of ..12922
Metals, separation from ore ..*13000
Metallurgy, theory and practice ..13148 13168
Meter, electricity, Teague ..*12900
Methacetin ..12961
Methylal ..12961
Methylene blue ..12961
Methylene chloride ..12961
Microbes of the soil ..*13102
Microcidine ..12961
Micro-organisms as insecticides ..13206
Microscope, objects for ..13010
Milk, citric acid in ..13318
Milk, fat in, estimation ..*13301
Milk, sterilizing ..*12962
Mills, cotton seed oil, in South ..13263
Mine locomotives, air ..*13304
Mine timbering ..*12935
Mines, diamond, African ..*13042
Minerals of N. South Wales ..13233
Mississippi, boating on ..13047
Mississippi River ..12948, 12963
Molasses, distillation of ..13151, 13165
Molecule, water ..13137
Monobromacetanilide ..12961
Morphine, violet color from ..13254
Moths ..13182
Motor, ether ..*13223
Mottling gun trimmings ..13261
Moulding machine, Smith's ..*13101
Mountain railways ..13117
Mount Blanc Observatory ..*13234
Mount St. Elias, height ..13310
Music, instruments of ..13064, 13097, 13089
Music, instrument of, new ..*13167
Myrtol ..12961

N

Naphthol ..12961
Naphthalene ..12961
Navy Yard, Boston ..13272
Nelson, battle ship ..*13319
Nervous affections, treatment ..13134 *13154
New York salt industry ..*13226
Nickel carbon oxide ..13147
Nitro-cellulose, manufacture ..13286
North River bridge ..*13211

O

Oak, red ..13011
Oats, albuminoid from ..13286
Obesity, treatment of ..13130
Observatory, modern, workin ..13214
Observatory, Mount Blanc ..*13234
Observatories, astronomical ..13061, 13071
Oil cooler ..*13194
Oil, cotton seed ..13261
Oil lemon, copper in ..13046
Oil, olive, production ..13310
Oils of lemons, etc ..13013
Oils, lubricating, refining ..13009
Olive oil, production ..13310
Ore, sampling, tool for ..*13310
Ores, refractory, treatment ..*13190
Orexin hydrachloride ..12961
Outline, distortion of ..12967
Oxygen through electrolysis ..*13079
Ozone, manufacture ..*13041

P

Padirac, puits de ..13202
Palace of Artaxerxes ..*13060
Palm, a new ..*12948
Palm, toddy ..*13058
Paper, photo., Willesden ..13110
Paper pulp, bleaching app ..*13133
Paper, tar, roll ..13112
Papier mache ..13042
Paraffin, origin of ..13240
Paraldehyde ..12961
Paramidophenol ..13053
Paris, Labor Exchange ..*13112
Paris, starch cleaning in ..13067
Parsley and hemlock ..13242
Parsnip, wild ..*13106
Patent decision, Edison ..13005
Peas, sweet ..13157
Penny-in-the-slot electric light ..13321
Pests, insect, killing ..*12977
Petroleum gas ..13046
Petroleum, origin of ..13240, 13241
Petroleum, refining of ..13000
Phenacetin ..12961
Phenylurethan ..12961
Phosphates, Florida, notes on ..12959
Phosphorus, action of fluorine ..12982
Phosphorus, chlorofluoride of ..13009
Phosphorus, electric manuf ..12943, 12957 13102
Photographic app., book ..*13238
Photographs, distortion of ..12967
Photographs, postage stamp ..*13082
Photographs sent by wire ..13307
Photography, astronomical ..12908
Photography on a black ground ..*13178 *13198, *13068
Photography, chemistry of ..13158, 13190 13215
Photography, kite ..*13215
Photography, some applica ..*13056
Photography, work by Herschel ..13020
Phthisis, preventive of ..13170
Physic, old and new ..13200
Pickle, berlinit ..13213
Pictures, electric transmis ..13307
Pigeon cotes, military ..*13088, *13102
Pines, Southern ..12903
Piperazide hydrochloride ..12961
Piston speeds, relative ..*13192
Planets, signaling to ..13106
Plants, acridity of, cause ..12942
Plants, bold leaved ..*13075
Plants, hybridization of ..13204
Plants of Louisiana ..12962
Plates, dry, sensitiveness ..13120
Plating, electro, hardness ..*13208
Platinum industry of Ural ..12981
Polarization of sugar ..*13138
Polarization tube, new ..*13198
Pomology ..13200
Portelectric transportation ..*12923
Postage stamp photographs ..*13022
Potassium chlorate, prep ..13005
Potassium nitrate, production ..12975
Potassium process, improved ..13213
Potato perforated by grass ..*13011
Pot-pourri ..13147
Powder, smokeless ..13114
Power, electric, storage system ..13251
Power, horse, electrical ..13101
Preservaline ..13212
Presidente Errazuris, ship ..*13102
Presidente Pinto, cruiser ..*13307
Press, filter ..*13108
Press, forging, hydraulic ..*13224
Presses, ancient ..*13228
Primuline process ..13022
Prince of Wales and family ..*13256
Printing process, new ..13041
Printing processes, recent ..13022
Prints, bronzing ..13276
Projector, Edison, new ..*13307
Propulsion, jet ..*12999
Puits de Padirac ..13202
Pulp bleaching apparatus ..*13133
Pulp, wood, soda ..13151
Puppies, breeding ..13172
Purification of water ..13227
Pyoctanin ..12961
Pyrodin ..12961
Pyridine ..12961

Q

Quadricycle, army ..*13177
Quarrying, modern methods ..*13190

R

Rag industry ..*13066
Railroads to the clouds ..13117
Rail spike and locomotive ..13292
Railway, cable, Los Angeles ..*13146
Railway, Central Africa ..*13048
Railway, electric, Budapest ..*12923
Railway, electric, London ..13128
Railway, rack, Abt ..*13015
Railway track, bearings for ..13093
Railways, electric, growth ..13017
Railways, electric, progress ..13143
Railways, ship, etc ..13004
Rain making, artificial ..*13159, 13161
Raisin industry, California ..13243
Ram, suction, universal ..*13210
Range finder, Welden's ..13247
Ranger, curve, Trotter ..*13291
Raphides in plants ..13242
Redoutable, ironclad ..*13127
Refrigerating apparatus ..*12908
Remedies, new ..12961
Reptile, fossil, Colorado ..*13071
Resin, sep. from fat acids ..13154, 13237
Resorcin ..12961
Retina, influence of repose on ..12945
Retort stand, new ..*13154
Retting, chemical ..13045
Rice cleaning in China ..13173
Rice, history of ..13157
Riparia bridge ..*13303
River, Mississippi ..12948, 12963
Rivet inserting machine ..*13321
Riveting ships, hydraulic ..13304
Road roller, improved ..*13018
Rocks under water, demolition ..*13128
Roller, road, improved ..*13018
Roofing paper, tar ..13112
Root cuttings ..*13106
Rope ascending apparatus ..*13225
Rope bridges ..*13163
Rubidium ammonio-bromide ..12931
Rudder of the Brennus ..*13272
Rugs, wire ..*13166

S

Safety device, electrostatic ..*12944
Sails, reefing from deck ..*13251
Salipyrin ..12961
Salol ..12961
Salt industry, New York ..*13226
Salts, preserving ..13213
Sampson, strongest man ..*13327
Sand filtration ..13026
Sazolith ..13213
Sausages, conservative for ..13213
Science Association, American ..13301
Scot, mail steamer ..*13000
Screens, yellow ..13041
Screw steamer Tynwald ..*13089
Sculptures, Greek ..13158
Separator, magnetic ..*13039
Sewage, detection of ..13230
Sewage, disposal of ..13236
Sewage disposal for towns ..13234
Shafts and wells, sinking ..13272
Shell flowers ..12919
Shield, hydraulic, Beach ..13003
Ship, battle, Nelson ..*13319
Ship Blanco Encalada, sinking ..*12951
Ship canal, German, new ..*12969
Ship Empress of India ..13267
Ship Great Eastern ..*13070
Ship Great Eastern, last of ..*13258
Ship Itata ..*13230
Ship Presidente Errazuris ..*13102
Ship Presidente Pinto ..*13307
Ship, turret, Hood ..*13063
Ship, turret, Marceau ..*13118
Ship of war Brennus ..*13272
Ship of war Cecilie ..*13032
Ship of war Jean Bart ..*12987
Ship of war Redoutable ..*13127
Ships, battle, armor plate on ..*13127
Shipbuilding, machine riveting ..13304
Shipmasters, hints to ..13294
Shovel, sampling ..*13310
Sibley College lectures ..*12952 13044, 13207
Sickness, sleeping, of West Africa ..13285
Silicon films ..12939
Silk, chemical nature ..*13239
Silk dresses and work ..13313
Silver, allotropic condition ..13302
Silver bullion, refining ..13091
Silver mining, Mongolia ..13039
Silver ores, electrolyt. pro ..13094
Silver, volatilization ..*12959
Sirups, preparation of ..13110
Slip for docking ships ..*13002
Smoke annihilator ..*12955, *13150
Snake River, bridge over ..*13303
Soap bubble blower ..*13283
Soap, Eschweger ..*13194
Soap, iodized ..13190
Soap for wool washing ..12960
Society, Royal, soirée ..12905
Soda wood pulp ..13151
Sodium and potass., manuf ..*13239
Sodium anisate ..12931
Sodium dithiosalicylate ..12931
Sodium paracresotate ..12931
Sodium process, improved ..*13213
Sodium nitrite, production ..12975
Sodium, light from ..*12998
Sodium theobromine ..12931
Soil, microbes of ..*13102
Solution, nature of ..13229
Somnal ..12931
Soul and germ plasm ..12946
Sound, aberrations of ..13010
Sounding apparatus, new ..*13195
Sozoiodal ..12931
Spectroscopy of dry plates ..13126
Spike, rail, and locomotive ..13292
Spruce, Douglas ..13012
Stampede tunnel ..*13207
Standards, electrical ..13199
Star, five-pointed, to make ..*13327
Starch into dextrin ..13013
Starch in leaves, formation ..*13138
Statues, how made ..12920
Steamer, mail, Scot ..*13000
Steamer Tynwald ..*13089
Steamer Utopia, raising ..*13007
Steamers, Atlantic, passages ..12954 13016
Steamships, idle ..13110
Steel, manganese in ..12934
Steel plates from molten metal ..13086
Stegosaurus, restoration ..*13071
Sterilizer, steam, Arnold ..*12962
Stilts, walking on ..*13122, *13234
Stock, live, on ranges ..13206
Stones, precious, U. S ..12942
Stoneware, apparatus ..*13072, *12991
Stoneware, manufacture ..13209
Storehouse, construction ..*13180
Stork, whale-headed ..*13243
Storks, education of ..*13074
Stove, thermo-electric ..*12967
Street cleaning in Paris ..13067
Sugar by diffusion process ..*13178
Sugar, examination tube for ..*13198
Sugar items, new ..13288
Sugar machine, centrifugal ..*13039
Sugars, estimation of ..*13138
Sulphate plant, box for ..*13045
Sulphides, auriferous, treatment ..13086
Sulphur, elim. from pig iron ..*13252
Sun dials ..*12946
Sun, motion of, in space ..13240

T

Talbot, photographic work ..13020
Tannin, chestnut wood ..13238
Tanning, electric ..*13006
Tar paper, roll ..13112
Taxidermy ..*13042
Teapot, automatic ..*13167
Telegraph, field, laying ..*12943
Telegraph message, first ..13229
Telephone as current measurer ..13022
Telephone, London-Paris ..*13131
Telescope, common, place for ..13297
Tennyson, Alfred ..*13295
Tent of a fumigator ..*12977
Terpene hydrate ..12961
Terpinol ..12961
Thalin sulphate ..13031
Therapeutics, cerebro-spinal ..13134 *13154
Thibet, fauna of ..*13208
Thiol ..12961
Thioresorcin ..12961
Tiger-netting in Bengal ..*12978
Timbering, mine ..*12935
Tin, early history of ..13280
Tin from waste tin plate ..*13151
Tin, our sources of ..13257
Tombs, Phenician, Cadiz ..*13298
Tool, sampling ..*13310
Torpedo boats, speed of ..13000
Torpedo finder ..13222
Tower, Eiffel, London ..*12999
Tracks, longitudinal bearings ..13093
Traction, by horses ..*13274
Tramway, electric, Budapest ..*12923
Transit, rapid, London ..12905
Transportation, portelectric ..*12923
Tribromphenol ..12961
Trional ..12941
Trout, parasite of ..13281
Tuberculine, effect on monkeys ..13261
Tunnel, Cascade ..*13207
Tunnel, street, Chicago ..*13095
Turbine, sugar ..*13039
Tyndall at home ..*13255
Tynwald, steamer ..*13089

U

Umbelliferæ, botany of ..13242
Universe, story of ..13092
Urethane ..12931
Utopia, raising of ..*13007

V

Vacuum discharges ..*12943, 12962
Valley of Jibos ..*13202
Vanilla ..13310
Vegetarianism ..13317
Vegetation of Louisiana ..13262
Vehicles, road, haulage ..*13274
Ventilation, gas for ..13062
Victoria cataracts, Brazil ..*13325
Villa, Roman, in England ..13122
Vina del Mar, battle of ..*13240
Vinegar, malt ..12975
Violet, morphine ..13254
Vision, notes on ..12961
Viscosity of gums ..*13109
Volcano of Bogaslov ..13281
Voltameters, forms of ..*13079
Volumetric analysis ..*13217
Von Helmholtz, Prof ..*13152

W

Wales, New So., minerals of ..13233
War, civil, in Chile ..*12951
Warship Brennus ..*13272
Warship Cecilie ..*13032
Warship Empress of India ..*12987
Warship Hood ..*13063
Warship Jean Bart ..*12987
Warship Marceau ..*13118
Warship Redoutable ..*13127
Warships, armor plate on ..*13127
Warp sizing machine ..*13100
Water, aeration of ..*12976
Water, distilling, feed app ..*13038
Water, electric evaporation ..*12958
Water, electrolysis of ..*13079
Water, hot, action on glass ..12975
Water, hot, electric supply ..*13181
Water molecule ..13137
Water, purification of ..*13023, 13270
Water, purification, electric ..12975
Water, purification of ..13227
Water supply systems, American ..12927
Waterway between great lakes ..12924
Wave power apparatus ..*13176
Weather debating society ..13161
Weaving, carpet, Persia ..13051
Weber, Wilhelm Eduard ..*13970
Weeds, migration of ..12976
Weighing machine, mercury ..*13250
Well, an East Indian ..*13051
Wells and shafts, sinking ..*13272
Whale fishery ..*13282
Wheat, composition of ..13242
Wheels, car, steel, casting ..*13146
Wheels, linked with bell crank ..*13247
Wild fowl shooting, Scotland ..*13297
Wine, citric acid in ..13318
Wine law, French ..13302
Wires, underground ..13116
Wollomombi Falls ..*13281
Wood pulp, soda ..13151
Woods, odorous ..13105
Wool washing, soap for ..12990
Workshops, American ..13289
World's of space, motions of ..13283
Worms in lead pipes ..13151

Y

Yaks, wild ..*13203
Yellow, cadmium ..12975
Yellow, chrome, manufact ..13166

Z

Zincographic process, new ..13041